User manual for *Meta-Essentials*: Workbooks for meta-analyses

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1 Introduction

Meta-Essentials is a set of workbooks that facilitate the integration and synthesis of effect sizes from different studies and provide figures, tables, and statistics that might be helpful for interpreting them. *Meta-Essentials* generates ("overall" or "meta") statistical information regarding a set of studies of the same phenomenon based on the statistical information from each separate study.

The workbooks and a pdf-version of this user manual can be downloaded from www.erim.eur.nl/research-support/meta-essentials.

1.1 Aim of this user manual

This user manual is a guide for the usage of the software tool. It is not a guide on how you should search for studies, which studies you should include, nor for how the results of the meta-analysis should be interpreted. We have written a separate text on these matters (see Hak, Van Rhee, & Suurmond, 2015b).

1.2 Structure

The first step when using *Meta-Essentials* is to choose the appropriate workbook for the meta-analysis. Then, this manual discusses how to insert data, how to perform a basic meta-analysis and to generate a forest plot, how to run a subgroup analysis, a moderator analysis, and various publication bias analyses. Also, the calculations 'behind' the sheets and the applied statistical methods are discussed, however, knowledge or understanding of these methods is not required for using *Meta-Essentials*. Next, the manual discusses those instructions that apply only to specific workbooks. This manual concludes with discussing guidance for how output of *Meta-Essentials* can be adapted for inclusion in a report.

1.3 Compatibility

The workbooks of *Meta-Essentials* are compatible with Microsoft Excel 2010, and 2013. Older versions of Excel might work fine in some cases, but several formulas and formatting features are not supported by these older versions. The screen prints in this manual are made with Microsoft Excel 2013, but are not too different from how it would look in earlier versions.

2 Select the appropriate workbook

Meta-Essentials is a set of seven different workbooks, each for meta-analysing a different type of effect size (which are explained shortly hereafter). Although the workbooks look the same, the calculations 'behind' them are different. From the user's perspective the most noticeable difference is that the workbooks require *different inputs*. An overview of the different workbooks is given in Table 1.

	File name	Type of effect	Example
	1. *Effect size data.xlsx*	Any, as long as directly comparable	Abnormal returns of bank loan announcements
Group differences	2. *Differences between independent groups - binary data.xlsx*	Difference between two independent groups with binary outcome	Counts of start-ups that did survive and did not survive after three years per gender of entrepreneur:
Group differences	3. *Differences between independent groups - continuous data.xlsx*	Difference between two independent groups with continuous outcome	The difference between the average sales of a team that received training and that of a team that did not receive training.
Group differences	4. *Differences between dependent groups - continuous data.xlsx*	Difference between two dependent groups with continuous outcome	The difference between the average sales of a team before and after receiving a training.
Relationships between variables	5. *Correlational data.xlsx*	Correlation between two variables	Relationship between investments in computer technology and business performance
Relationships between variables	6. *Partial correlational data.xlsx*	Relation between two variables, controlled for other variable(s) in both predictor and outcome	Idem, but controlled for type of technology
Relationships between variables	7. *Semi-partial correlational data.xlsx*	Relation between two variables, controlled for other variable(s) in outcome	Idem, but controlled for average industry performance

	Did survive	Did not survive
Male	A	B
Female	C	D

Table 1: Overview of the Meta-Essentials workbooks

Workbook 1, *'Effect size data.xlsx'*, can be considered the *generic* one. This workbook can be used when the user has (1) the point estimate of the effect size *and* (2) its standard error. The effect sizes of the different studies must be comparable or, in other words, they must be sizes on the same scale. Workbook 1 can only be used for effect sizes on a continuous scale on which the intervals have the same weight or meaning at every point on the scale. This scale can be an unstandardized one (such as millimetres, minutes, grams, dollars, regression weights, etc.) or a standardized one (Cohen's *d*, Hedges' *g*). Intervals between standardized regression weights and between correlation coefficients are *not* the same in this sense, and hence the generic workbook 1 cannot be used for meta-analysing that type of effect size. Workbooks 5, 6 and 7 can be used for meta-analysing correlation coefficients and results of a multiple regression analysis.

Workbooks 2 to 7 are basically extended versions of workbook 1. They perform calculations and transformations that precede the meta-analysis proper. These include calculations of effect sizes of studies that do not report them, and transformations of effect sizes to more suitable scales. Each one of the workbooks 2 to 7 does this for a *specific* type of effect size. To decide which workbook you should use, you must first determine whether your effect size is of the 'difference family' or of the 'correlation family'. The difference family, or d-family, regards effect sizes that are based on differences between or within groups; you can use workbook 2, or 3 or 4. The 'correlation family', or

r-family, regards effect sizes based on the association between two (or more) continuous variables; you can use workbook 5, 6, or 7.

If your effect size is of the d-family, you can find guidance about how to make a choice between workbooks 2, 3 and 4 in the following section. If your effect size is of the r-family, you can find guidance about how to make a choice between workbooks 5, 6 and 7 in the section thereafter.

2.1 Effect sizes of the d-family

Research designs in the d-family can be categorized along two dimensions:

1. The dependent variable can be categorical or continuous. This difference results in different types of effect size, namely a difference between proportions if the dependent variable is categorical and a difference between means if the dependent variable is continuous.
2. The difference that is studied can be a difference between different groups or a within-group difference. Examples of the first type ("independent groups") are experiments with separate groups and non-experimental differences between separate categories (e.g., between men and women, or between different types of companies). An example of the second type ("dependent groups") is a difference in time, for instance before and after a therapy or other intervention.

Four types of studies with a *d*-design can be distinguished based on these two dimensions (see Table 2). Workbooks 2, 3 and 4 each fill one of the cells in table. The cell for categorical dependent variable with dependent groups is empty because this type of design is very rare. Should you want to meta-analyse effect sizes of such type you can use workbook 1 *'Effect size data.xlsx'*.

	Independent groups	**Dependent groups**
Categorical dependent variable	2. *Differences between independent groups - binary data.xlsx*	
Numerical dependent variable	3. *Differences between independent groups - continuous data.xlsx*	4. *Differences between dependent groups - continuous data.xlsx*

Table 2: Overview of the Meta-Essentials workbooks of the d-family

Workbook 2 *'Differences between independent groups - binary data.xlsx'* can be used for meta-analysing studies that compare two groups (typically an experimental group and a control group) when the outcome of interest is categorical (e.g., success versus failure). This is a common research design in clinical studies but could be applied in social sciences as well. For instance, the relationship of the gender of an entrepreneur with the one-year survival (survival versus bankruptcy) of a start-up could in one study be evaluated with a two-by-two table. Typical statistics to grasp the size of difference in such studies are the odds ratio, risk ratio, and the risk difference.

Workbook 3 *'Differences between independent groups - continuous data.xlsx'* is designed to meta-analyse studies of which the outcome is a difference between the means of two independent groups. For instance, to test whether a training has a positive effect on the sales of sales personnel, a study might be designed that gives one group of salespersons a training and another group no training. The effect size of interest would then be the difference between the average sales of the persons that received training compared to that of the persons that did not receive training.

Workbook 4 *'Differences between dependent groups - continuous data.xlsx'* is designed to meta-analyse studies of which the outcome is a difference between the means of two measurements in the same group. In comparison to the previous example, this is the effect size in a study of a difference in sales in the same group of persons *before* and *after* training. This is often referred to as

a pre-posttest study design. On the face of it, there are few differences between workbooks 3 and 4. However, the calculations 'behind' the workbooks are different.

2.2 Effect sizes in the r-family

There are two common types of effect size in the r-family: correlation coefficients (which are unit free by definition) and regression weights (which can be unstandardized or standardized). Unstandardized regression weights will almost never be meta-analysed because this would require that all studies would use exactly the same measurement instruments (with the same scales) for both the independent and dependent variable. However, in the exceptional case that the user has this type of data, the user could also use the generic workbook 1, assuming that the standard errors are available as well.

Workbook 5 *'Correlational data.xlsx'* is designed to meta-analyse bivariate correlations. Generally, when people refer to 'correlations' they mean this type of correlation, which is sometimes also referred to as Pearson's correlation.

All workbooks discussed so far (2-5) are used to meta-analyse effect sizes for bivariate effects. However it is very common, in studies with effect sizes of the r-family that the 'effect' of a set of multiple independent variables on an independent variable is studied. A problem for meta-analysis is that it is very rare that the same set of independent variables (with the same method of measurement) is used across all studies. This means that the regression weights generated in different studies cannot be compared directly, because they are 'controlled' for different sets of other independent variables. The remaining workbooks 6 and 7 provide two slightly different solutions for this situation.

Workbook 6 *'Partial correlational data.xlsx'* is designed to meta-analyse *partial* correlations of two variables, that is, the correlation between two variables controlled for other variables. Or more formally, the part of the predictor that is related with the outcome variable after a portion of the effect (the portion that is explained by other additional variables) is partialled out. This effect size can be used when you are interested in the relation between two variables, while controlling for other variables in both the predictor and the dependent variable. The workbook can calculate partial correlations from commonly reported multiple regression results.

Workbook 7 *'Semi-partial correlational data.xslx'* is designed to meta-analyse the *semi-partial* correlation between two variables, but removes only the variance explained by additional variables from the outcome and not from the focal predictor. The semi-partial correlation is sometimes referred to as 'part correlation'. This effect size can be used when you are interested in the relation between two variables, while controlling for other variables in only the predictor. The workbook can calculate semi-partial correlations from commonly reported multiple regression results.

3 Work with the workbooks

Each workbook of *Meta-Essentials* consists of six sheets, each of which can be accessed on screen by clicking a tab at the bottom of the page (see Figure 1).

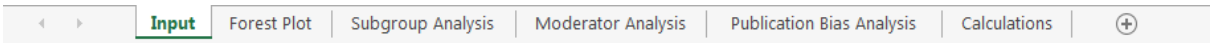


Figure 1: The tabs to access the six sheets of Meta-Essentials

The first sheet is the *Input* sheet. This is the sheet where you enter the information from the studies that you want to include in your meta-analysis. The next four sheets are *output* sheets: one for the forest plot, one for the subgroup analysis, one for the moderator analysis, and one for the publication bias analyses. The sixth sheet contains the *calculations* that are performed for producing the four output-sheets. For basic use of the workbooks there is no need for you to look at, or work with this sheet.

The six sheets of a *Meta-Essentials* workbook will be discussed below, with screenshots. The examples used in these screenshots come from analyses in workbook 1 *'Effect size data.xlsx'* with fictitious data. All six sheets of all seven workbooks are essentially the same. Features that are specific to a certain workbook are discussed in a separate section.

Different *colours* mark different purposes of cells. Cells in which the user can give input or change settings are always coloured in *pink*, calculations in *dark grey,* and output in *lighter grey* (see Table 3).

Purpose	Cell colour
User's input/choice	
Calculation	
Output	

Table 3: Purpose of cell colours

The user is free to make changes in the files, **but we advise the novice user not to change any cells, except the ones coloured in pink**, which are designed for user input. It is advised in particular **not to insert or delete any columns or cells in the calculations sheet** because this might distort the calculations. In case you run into trouble, you can try running a meta-analysis in a 'fresh' workbook of *Meta*-Essentials. You can easily do this by copying the data that you have filled in the *Input* sheet, and paste that in the 'fresh' workbook. It is recommended to use the option *paste values* which is available under 'Paste options' when right-clicking (see the red rectangle in Figure 2).

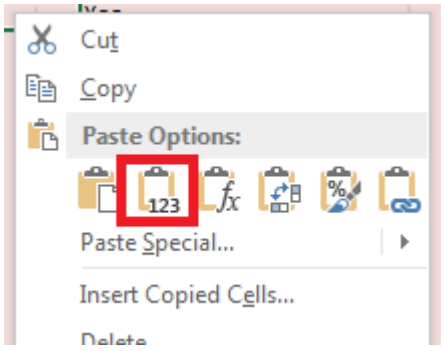


Figure 2: The right-click menu for pasting values

3.1 Input sheet

By default the sheet that you will see when you open a workbook is the Input sheet. If not, you can access it by clicking on the regarding tab, as shown in Figure 3. The Input sheet of workbook 1 *'Effect size.xlsx'* has nine columns. Input is *required* only in the columns for 'Effect size' and 'Standard error' (see 'Required data' in Figure 4).

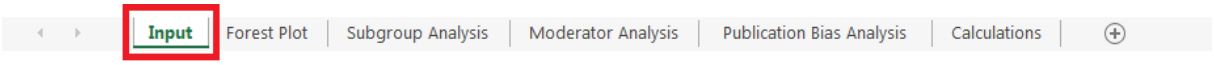


Figure 3: The tab to access the Forest Plot sheet of Meta-Essentials

#	Study name	Include study	Effect size	Standard error	Number of observations (for CIs)	Sufficient data	Subgroup	Moderator
1	aaaa	Yes	2.20	0.25	100	Yes	AA	15
2	bbbb	Yes	1.80	0.21	130	Yes	AA	16
3	cccc	Yes	1.90	0.27	80	Yes	AA	13
4	dddd	Yes	2.05	0.14	300	Yes	AA	18
5	eeee	Yes	0.05	0.20	95	Yes	BB	20
6	ffff	Yes	-0.60	0.21	90	Yes	BB	14
7	gggg	Yes	2.00	0.22	120	Yes	AA	19
8	hhhh	Yes	1.80	0.21	130	Yes	AA	13
9	iiii	Yes	0.40	0.22	80	Yes	BB	19
10	jjjj	Yes	2.10	0.16	240	Yes	AA	22
11	kkkk	Yes	-0.40	0.21	90	Yes	BB	17
12	llll	Yes	-0.50	0.20	100	Yes	BB	18
		Optional		Required		Optional		Optional

Figure 4: Example of the Input sheet

In workbook 1 you need to insert the number of observations (i.e., the sample size) for an estimation of the individual study confidence intervals, because the degrees of freedom of the *Student's T*-distribution are based on them. I.e., the number of observations is not necessary for calculating a meta-analytical effect size, nor for any of the additional analysis but is necessary for calculation of confidence intervals for the individual studies (as presented in the forest plot).

Not required but probably useful are the following inputs:

- Entering a *name or other identifier* of a study ('Study name'). The study name can be any name you choose; it works best if you use a unique name for each study.
- Assigning membership to a *subgroup* ('Subgroup'). The *subgroup* must be a *categorical* variable which can be used in the subgroup analysis. You can enter the categories of this variable in any way you want: numerical, textual, or combinations thereof.
- Entering a score for another feature of the population studied or for the study ('Moderator'). The *moderator* is a *continuous* variable which might be used in the moderator analysis. The moderator must be a numerical variable which is assumed to have at least an interval scale.
- Deciding whether a study will be *included* in a meta-analyses ('Include study'). The study will be included by default ('Yes'). This can be changed by using a dropdown menu, which can be accessed by clicking on the cell and then clicking on the small arrow next to the cell (Figure 5). You can also type "Yes" or "No".

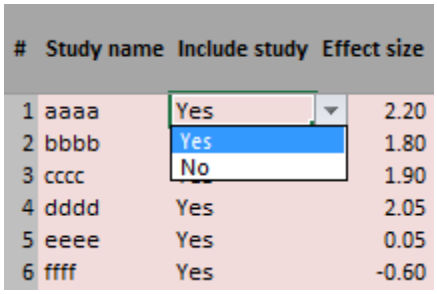


Figure 5: Example of 'Include Study' on the Input sheet

If "No" is selected for a particular study, this study will be omitted from all analyses, including the subgroup analysis, moderator analysis, and publication bias analyses.

The cells in the column *'#'* will automatically indicate a number for the order of entry in the input sheet. It will only indicate a number if both 'Include study' and 'Sufficient data' are "Yes".

The cells in the column 'Sufficient data' automatically indicate whether sufficient data is entered for inclusion of the study in the meta-analysis. In workbook 1 *'Effect size data.xlsx'* it is set to "Yes" (indicating sufficiency) whenever the effect size and standard error for a particular study have been entered. In the other workbooks, different criteria for sufficiency are applied. These will be discussed for each of them separately in the section that describes features that are specific to a certain workbook.

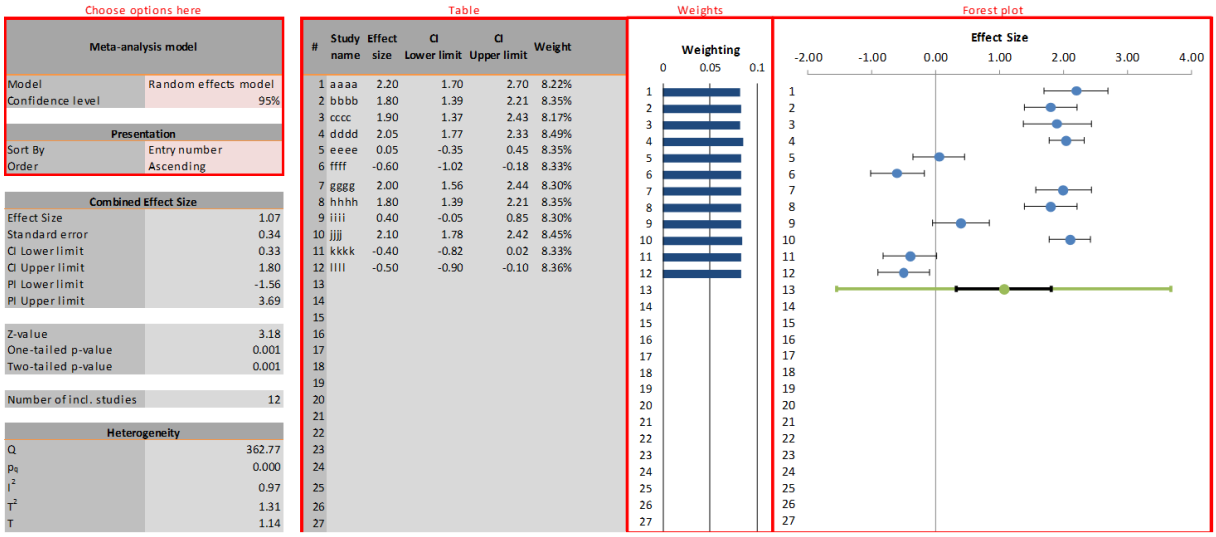


Figure 6: Example of the Forest Plot sheet

3.2 Forest Plot sheet

The Forest Plot sheet, which you can open by clicking on the regarding tab as shown in Figure 7, consists of three parts. On the left side, a number of statistics is presented that are generated by *Meta-Essentials*. Four important pieces of information are a) the (combined) effect size, b) the lower and upper limits of its confidence interval (CI), c) the lower and upper limits of its prediction interval (PI), and d) several heterogeneity statistics. In the middle, a table is given with the individual study results (see the red rectangle labelled 'Table' in Figure 6) and a graphical representation of the weights assigned to the studies in the meta-analysis. Finally, on the right side, the 'forest plot' pictures the effect size (with confidence interval) of each study and, below them, (a) the combined

effect size with its confidence interval (in black colour) and its prediction interval (in green colour). These are the basic outcomes of any meta-analysis.

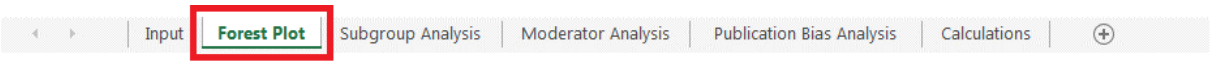


Figure 7: The tab to access the Forest Plot sheet of Meta-Essentials

3.2.1 Choose options

In the top left corner of the sheet (see the red rectangle labelled 'Choose options here' in Figure 6) the user can make some choices regarding the meta-analysis itself ('random effects' versus 'fixed effects', and confidence level) and regarding the ordering of studies on the output sheets (sorting criterion and sorting order).

The user can choose between a 'fixed effects' model and a 'random effects' model. In the '*fixed* effects' model it is assumed that all differences between effect sizes observed in different studies are due to sampling error only. In other words, the (unobserved) 'true' effect is assumed to be the same for each study and the studies are functionally equivalent. The aim of the meta-analysis is to estimate that true effect and the combined effect size (and its confidence interval) are interpreted as an estimate of the 'true' effect. In the '*random* effects' model it is assumed that it is possible (or likely) that different 'true' effects underlie the effect sizes from different studies. The aim of the meta-analysis is to estimate (and then explain) the variance of these true effects and the prediction interval is interpreted as an estimate of that variance or dispersion (for a more detailed discussion of these models see, e.g., Hedges & Vevea, 1998). In *Meta-Essentials* the random effects model is used by default because the assumptions underlying the fixed effects model are very rarely met, especially in the social sciences. Furthermore, when a fixed effects model would make sense to use, i.e., when there is little variance in effect sizes, the random effects model converges automatically into a fixed effects model.

3.2.2 Prediction Interval

The *Meta-Essentials* software does not only generate a confidence interval for the combined effect size but additionally a 'prediction interval'. Most other software for meta-analysis will not generate a prediction interval, although it is - in our view - the most essential outcome in a 'random effects' model, i.e. when it must be assumed that 'true' effect sizes vary. If a confidence level of 95% is chosen, the prediction interval gives the range in which, in 95% of the cases, the outcome of a future study will fall, assuming that the effect sizes are normally distributed (of both the included, and not (yet) included studies). This in contrast to the confidence interval, which "is often interpreted as indicating a range within which we can be 95% certain that the true effect lies. This statement is a loose interpretation, but is useful as a rough guide. The strictly-correct interpretation [… is that, i]f a study were repeated infinitely often, and on each occasion a 95% confidence interval calculated, then 95% of these intervals would contain the true effect." (Schünemann, Oxman, Vist, Higgins, Deeks, Glasziou, & Guyatt, 2011, Section 12.4.1). As this is a user manual for the software of *Meta-Essentials* and not an introduction to the aims and best practices of meta-analysis, we cannot expand here on the importance of the prediction interval vis-à-vis the confidence interval (but see, e.g., Hak, Van Rhee, & Suurmond, 2015a; Higgins, Thompson, & Spiegelhalter, 2009).

3.3 Subgroup Analysis sheet

When the user has entered a category in the 'Subgroup' column of the Input sheet, then the Subgroup Analysis sheet will present meta-analytic results for each subgroup separately. For instance, if the user has coded the origin of the data used in a study as either 'USA' or 'Non-USA', this sheet will give a combined effect size for the 'USA' studies and another combined effect size for the

'Non-USA' studies, as well as an combined effect size for all included studies. You can access the sheet by clicking on the regarding tab, as shown in Figure 8.

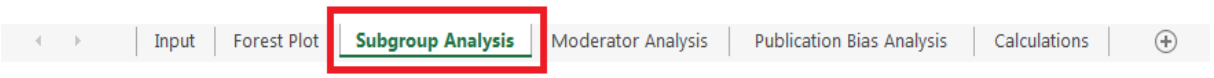


Figure 8: The tab to access the Subgroup Analysis sheet of Meta-Essentials

The left side of this sheet is similar to the left side of the Forest Plot sheet (see Figure 9). For the sake of clarity we make us of a feature of Microsoft Excel that offers the opportunity to 'hide' certain columns. These parts can be accessed by clicking the plus sign at the top of the column (see Figure 10). When the first plus is clicked, a table appears with individual study results, combined effect sizes per subgroup and the overall combined effect size (see Figure 11).

Meta-analysis model	
Between subgroup weighting	Random effects
Within subgroup weighting	Random effects (Tau pooled over subgroups)
Confidence level	95%
Number of incl. subjects	1555
Number of incl. studies	18
Combined Effect Size	
Effect Size	0.89
Standard error	1.10
CI Lower limit	-1.44
CI Upper limit	3.22
PI Lower limit	-3.14
PI Upper limit	4.92
Subgroup heterogeneity	
Q_{within}	18.39
$p_{Q,within}$	0.30
$Q_{between}$	131.80
$p_{Q,between}$	0.00
Q_{total}	362.77
$P_{Q,total}$	0.00
R^2	36.33%

Figure 9: Example of the left part of the Subgroup Analysis sheet

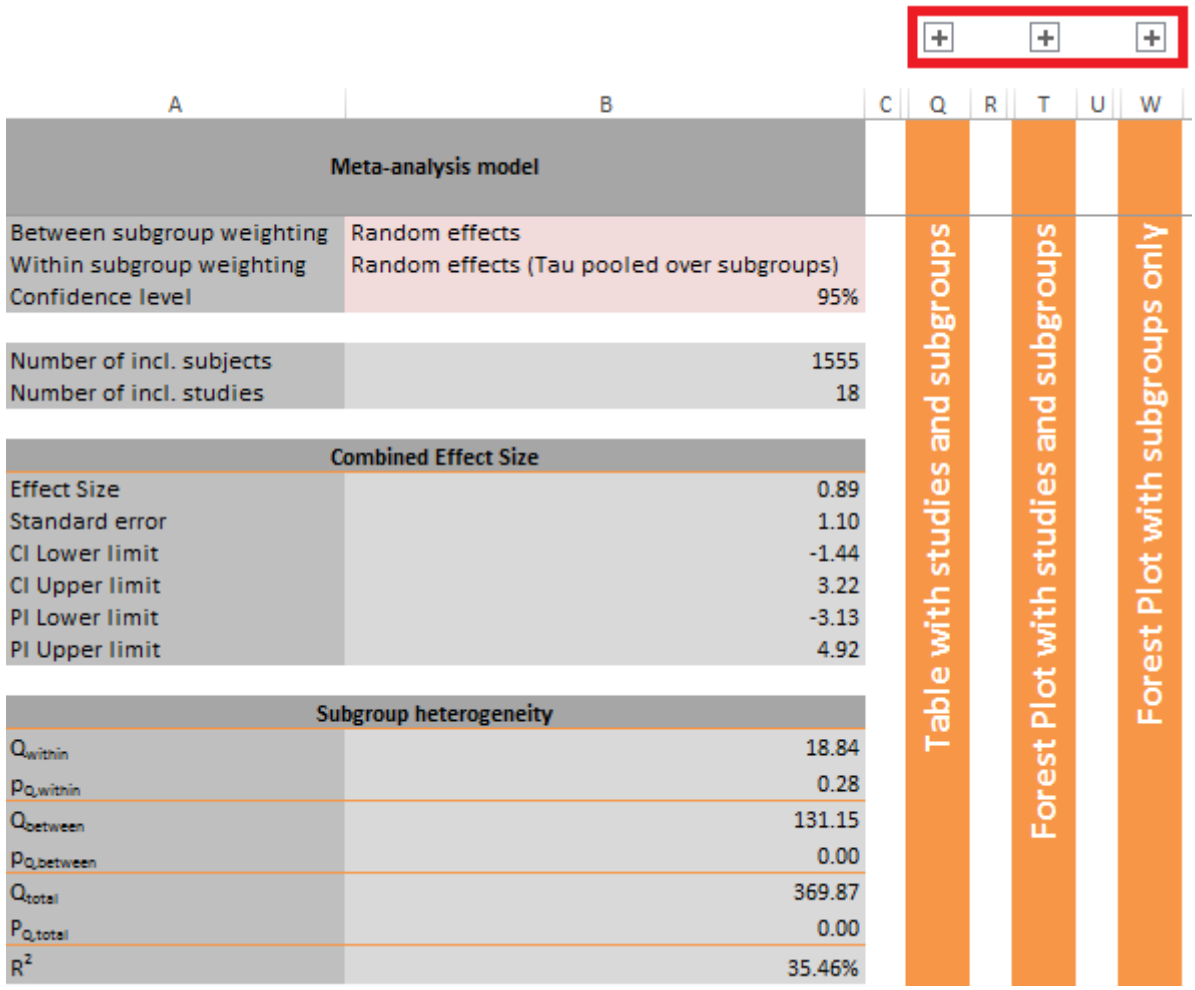


Figure 10: Example of plus signs in the Subgroup Analysis sheet that can be clicked to 'unhide' a set of columns

	#	Study name / Subgroup name	Effect size	CI LL	CI UL	Weight	Q	p_Q	I^2	T^2	T	PI LL	PI UL
	1	aaaa	2.20	1.70	2.70	9.59%							
	2	bbbb	1.80	1.39	2.21	13.36%							
	3	cccc	1.90	1.37	2.43	8.65%							
	4	dddd	2.05	1.77	2.33	23.39%							
	5	gggg	2.00	1.56	2.44	11.85%							
	6	hhhh	1.80	1.39	2.21	13.36%							
	7	jjjj	2.10	1.78	2.42	19.79%							
Subgroup AA	8	**AA**	**1.99**	**1.88**	**2.10**	**50.32%**	**3.14**	**0.791**	**0.00%**	**0.01**	**0.10**	**1.77**	**2.21**
	9	eeee	0.05	-0.35	0.45	21.07%							
	10	ffff	-0.60	-1.02	-0.18	19.50%							
	11	iiii	0.40	-0.05	0.85	18.08%							
	12	kkkk	-0.40	-0.82	0.02	19.90%							
	13	llll	-0.50	-0.90	-0.10	21.45%							
Supgroup BB	14	**BB**	**-0.22**	**-0.58**	**0.14**	**49.68%**	**15.25**	**0.004**	**73.77%**	**0.01**	**0.10**	**-0.63**	**0.19**
Combined effect size	15	**Combined effect size**	**0.89**	**-1.44**	**3.22**		**362.77**	**0.000**	**95.31%**	**1.28**	**1.13**	**-3.14**	**4.92**

Figure 11: Example of 'Table with studies and subgroups' of the Subgroup Analysis sheet

Furthermore, two types of forest plots are available: one with studies, subgroups and combined effect (see Figure 12) and one with subgroup and combined effects only, which enhances the comparison of subgroups (see Figure 13). In these plots, blue dots represent individual studies, red dots represent subgroups, and the green dot represents the combined effect size. Also the prediction

intervals are shown for the subgroups and combined effect size in their respective colours, whereas the confidence interval is shown in black. Note that because the confidence interval of the first subgroup in the example of Figures 9 and 10 is so small that it disappears almost entirely behind the red dot.

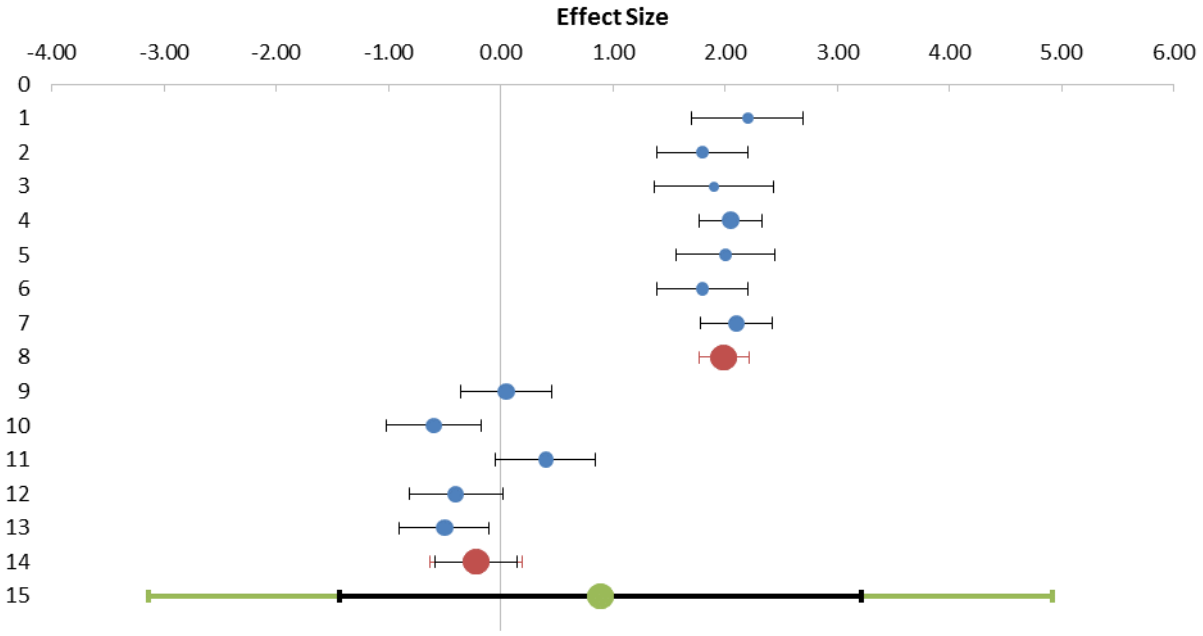


Figure 12: Example of 'Forest plot with studies and subgroups' part of the Subgroup Analysis sheet

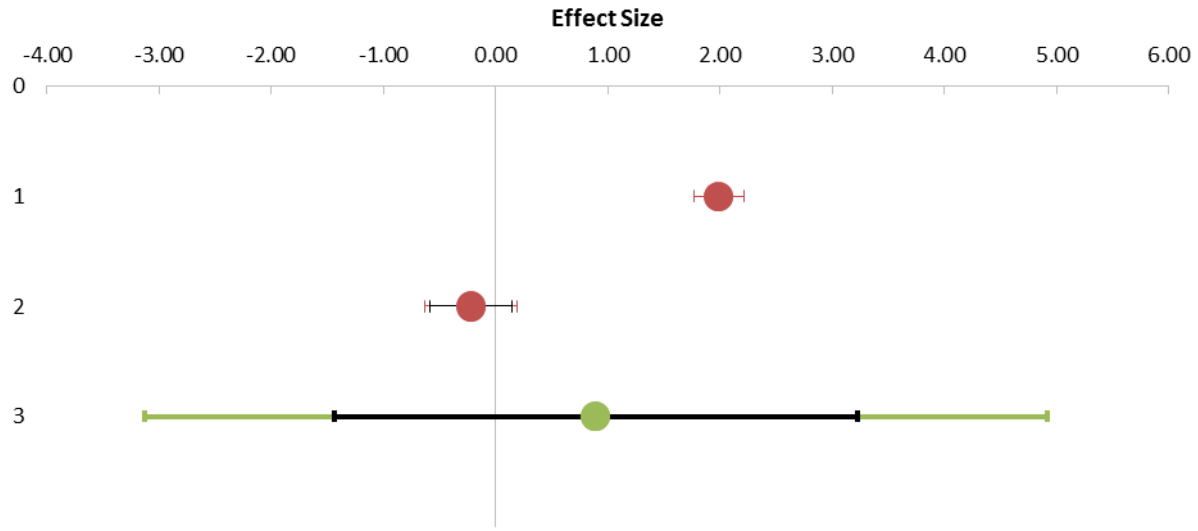


Figure 13: Example of 'Forest plot with subgroups' part of the Subgroup Analysis sheet

3.3.1 Options

The user must choose how to distribute weights to studies between subgroups and within subgroups (see the red rectangle labelled 'Choose options here' in Figure 9). For the 'Between subgroup weighting' the user can choose from a 'Fixed effects' and 'Random effects' (default) model. For the 'Within subgroup weighting', the user can choose between 'Fixed effects', 'Random effects (*Tau* separate for subgroups)' (default), and 'Random effects (*Tau* pooled over subgroups)' models. If the latter option is selected, the variance components (*Tau*) of each subgroup will be pooled (averaged) and used for every subgroup. Note that these defaults are not always appropriate to use. Theory will

have to tell which option to use; in general, using pooled variance components is more appropriate when you have very few studies included in your meta-analysis or in any particular subgroup (Borenstein, Hedges, & Higgins, 2009, pp. 149 ff).

3.3.2 Heterogeneity

The 'Heterogeneity' part of the sheet is more complex than the one in the Forest Plot sheet, because it contains measures on three levels: within, between, and total (See 'Assess heterogeneity' in Figure 9). The total heterogeneity (variance) is the heterogeneity among all studies, ignoring the structure of the data (i.e., the subgroups). The heterogeneity within subgroups states how much of the total variance is within the subgroups. The heterogeneity between subgroups states how much of the total variance is explained by assigning subgroups to the studies. Higgins et al. (2003) discuss how to interpret values for heterogeneity statistics for subgroup analyses.

3.4 Moderator Analysis sheet

If you entered a score in the 'Moderator' column of the Input sheet, then a weighted regression will be run with 'Moderator' as a predictor of the effect size of a study. In *Meta-Essentials*, it is not possible to run a multivariate regression analysis, so only one moderator can be assessed at a time. You can access the Moderator Analysis sheet by clicking on the regarding tab, as shown in Figure 14.

Figure 14: The tab to access the Moderator Analysis sheet of Meta-Essentials

On the left of the sheet (displayed in Figure 15), the user can choose between a 'fixed effects' model and a 'random effects' model. The user can also set the confidence level. As in other sheets, the random effects model is set as default. Also a table is provided with some essential statistics per study.

Meta-analysis model	
Model	Random effects
Confidence level	95%

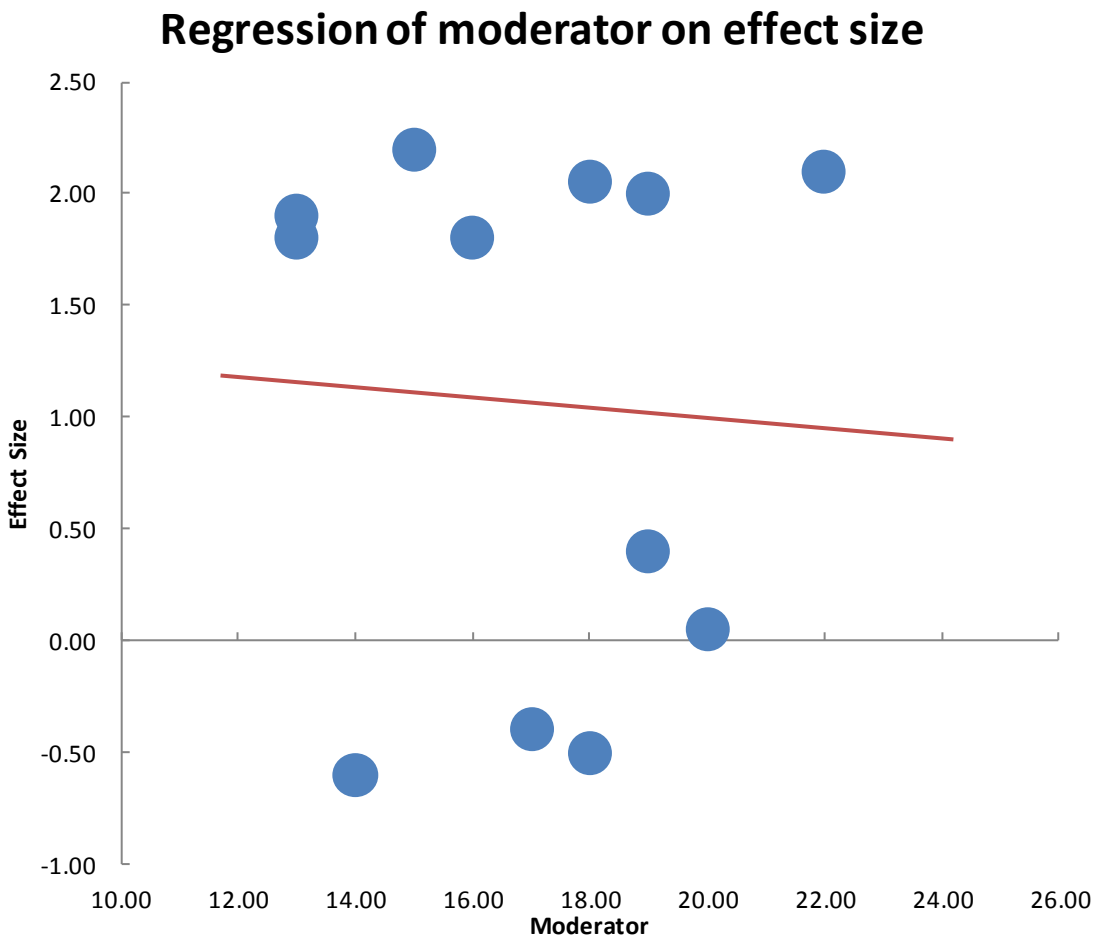
Choose options here

Study name	Effect size	Moderator	Weight
aaaa	2.20	15.00	8.23%
bbbb	1.80	16.00	8.34%
cccc	1.90	13.00	8.19%
dddd	2.05	18.00	8.47%
eeee	0.05	20.00	8.35%
ffff	-0.60	14.00	8.33%
gggg	2.00	19.00	8.31%
hhhh	1.80	13.00	8.34%
iiii	0.40	19.00	8.30%
jjjj	2.10	22.00	8.44%
kkkk	-0.40	17.00	8.33%
llll	-0.50	18.00	8.36%

Table

Figure 15: Example of part of the left part of the Moderator Analysis sheet

The most important result of this regression is the coefficient (*B*) of the slope (see red rectangle in Figure 16), which is an estimate of the association between the moderator and a study's effect size. This is also visualized in the plot (also shown in Figure 16), where the effect sizes of the studies are plotted against their moderator values and a regression line through these points. Note that the size of the dots represents their relative weight. However, since in the example all studies receive about the same weight, the dot sizes appear to be equal.



	B	SE	CI LL	CI UL	β	Z-value	p-value
Intercept	1.45	2.22	-3.43	6.33		0.66	0.512
Slope	-0.02	0.13	-0.31	0.26	-0.06	-0.18	0.860

Fit statistics	Q (Sum of squares)	df	p_Q	Mean square	F-Value	p-value
Model	0.03	1	0.860	0.03	0.03	0.863
Residual	9.92	10	0.448	0.99		
Total	9.95	11	0.535			

Combined effect size	1.07
T^2 (method of moments estimation)	1.45
R^2	0.31%

Figure 16: Example of right part of the Moderator Analysis sheet

3.5 Publication Bias Analysis sheet

Publication bias analysis is not a core meta-analysis feature and for some of the methods rather strong assumptions apply, which means they should be used with caution (see Hak et al., 2015a).

Multiple procedures or statistics regarding publication bias analysis are provided by *Meta-Essentials*: funnel plot, Egger regression, Begg and Mazumdar's rank correlation test, standardized residual histogram, Galbraith plot, normal quantile plot, and several failsafe-*N* tests. They can be accessed by clicking on the regarding tab, as shown in Figure 17.

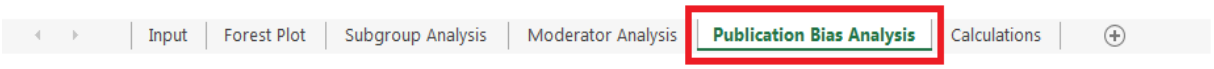


Figure 17: The tab to access the Publication Bias Analysis sheet of Meta-Essentials

Because most of the publication bias analyses only make sense for a fixed effects model, we have set that as default for this sheet. You might, however, change it to random effects model in the table on the left of the sheet, where you can set the confidence level for confidence and prediction intervals as well (see red rectangle labelled 'Choose options here' in Figure 18).

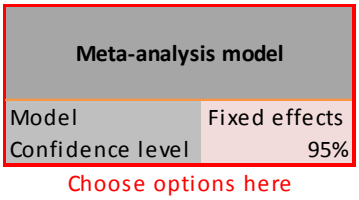


Figure 18: Example of left part of Publication Bias Analysis sheet

As in the Subgroup Analysis sheet, the user must click on the plus sign to open a particular procedure (see red rectangle in Figure 19).

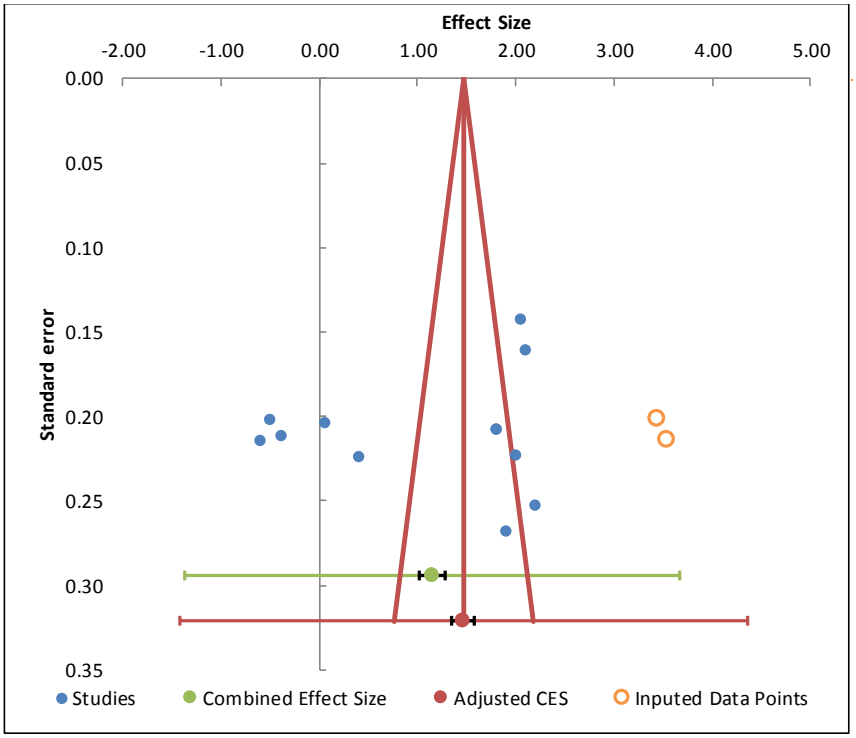
Figure 19: Example of right part of Publication Bias Analysis sheet

3.5.1 Funnel plot

A funnel plot (see Figure 20) is a scatter plot of the studies in a meta-analysis (represented by blue dots) in a space defined by effect size (on the x-axis; scale displayed on top of the plot) and standard error (on the y-axis). It also presents the combined effect size (green dot) with its confidence interval (black) and prediction interval (green). The plot also shows a vertical line (also in red) that runs through the (adjusted) combined effect size and the corresponding lower and upper limits of the confidence interval (red diagonal lines).

The adjusted combined effect size and accompanying confidence and prediction intervals in this plot represents the results of a trim-and-fill procedure as proposed by Duval and Tweedie (2000a; 2000b).

Study name	Effect Size	Standard Error
aaaa	2.20	0.25
bbbb	1.80	0.21
cccc	1.90	0.27
dddd	2.05	0.14
eeee	0.05	0.20
ffff	-0.60	0.21
gggg	2.00	0.22
hhhh	1.80	0.21
iiii	0.40	0.22
jjjj	2.10	0.16
kkkk	-0.40	0.21
llll	-0.50	0.20



Combined effect size	Observed
Effect Size	1.15
SE	0.06
CI Lower limit	1.02
CI Upper limit	1.28
PI Lower limit	-1.37
PI Upper limit	3.67

Combined effect size	Adjusted
Effect Size	1.47
SE	0.05
CI Lower limit	1.35
CI Upper limit	1.58
PI Lower limit	-1.43
PI Upper limit	4.36

Heterogeneity	Adjusted
Q	580.86
p_Q	0.000
I^2	0.98
T^2	1.79
T	1.34

Trim and Fill	On
Search from mean	Right
Estimator for missing studies	Leftmost Run/Rightmost Run
Number of imputed studies	2

Choose Trim-and-Fill options here

Figure 20: Example of funnel plot part of the Publication Bias Analysis sheet

The user can turn the trim-and-fill procedure 'On' or 'Off'; can decide whether to search for studies missing in the meta-analysis on the 'Left' or 'Right' side of the combined effect size; and can choose between two estimators: 'Linear' (also described as L_0^+) or 'Leftmost / Rightmost Run' (also described as R_0^+). Once the trim-and-fill is turned on, *Meta-Essentials* will calculate an adjusted combined effect size (with CI and PI, represented on the red horizontal line in Figure 11) as well as adjusted heterogeneity measures. These adjusted statistics are based upon the set of initially included studies expanded with the imputed data points (orange open circles in the plot, see Figure 20).

3.5.2 Egger regression and Begg and Mazumdar rank correlation test

The Egger regression gives "the degree of funnel plot asymmetry as measured by the intercept from regression of standard normal deviates against precision" (Egger, Smith, Schneider, & Minder, 1997, p. 629). The output on this sheet consists of this intercept (and its confidence interval) as well as of the outcome of a *t*-test (*t*-value and *p*-value) (see Figure 21 for an example).

Egger Regression				
	Estimate	SE	CI LL	CI UL
Intercept	-9.09	9.61	-30.23	12.05
Slope	2.95	1.93	-1.30	7.19

t test	-0.95
p-value	0.366

Figure 21: Example of Egger regression part of the Publication Bias Analysis sheet

The Begg and Mazumdar rank correlation test uses the correlation between the ranks of effect sizes and the ranks of their variances (Begg & Mazumdar, 1994, p. 1088). This sheet presents (a) the difference between concordant and discordant ranks (*Δx-y*), (b) the rank correlation (Kendall's *Tau a*), (c) a *z*-value as well as (d) a *p*-value for this correlation (see Figure 22 for an example).

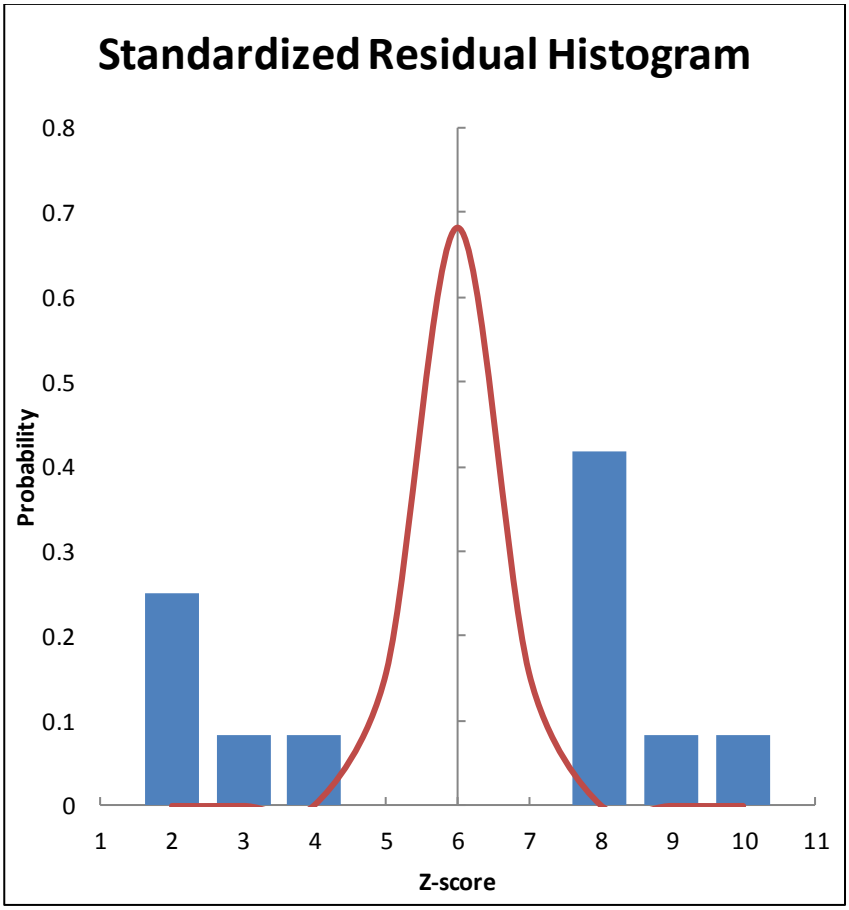
Begg & Mazumdar's rank correlation test	
Δx-y	-5
Kendall's Tau a	-0.08
z-value	-0.34
p-value	0.366

Figure 22: Example of Begg and Mazumdar's rank correlation test part

3.5.3 Standardized Residual Histogram

The Standardized Residual Histogram is based on the idea that the *z*-scores of individual studies, also known as standardized residuals, are expected to follow a normal distribution around the combined effect size (Sutton et al., 2000, p. 41). To assess whether there are outliers in the effect sizes, one could put the residuals in bins and plot them against a standard normal distribution. The standardized residuals are arranged in 9 bins and the proportion of residuals in that bin determines the height of the bar (see Figure 23 for an example).

Study name	Standardized residual
aaaa	4.62
bbbb	3.69
cccc	3.19
dddd	7.56
eeee	-5.20
ffff	-8.10
gggg	4.34
hhhh	3.69
iiii	-3.08
jjjj	6.91
kkkk	-7.22
llll	-8.11



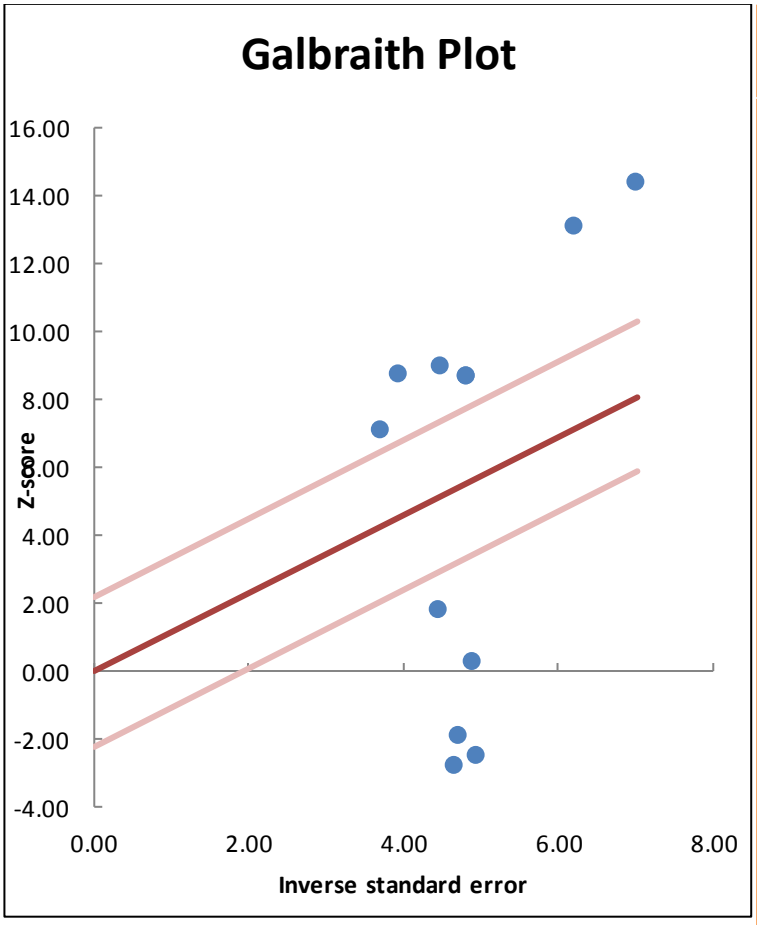
Bin #	Display	Proportion	Probability
1	-∞; -7	0.25	0.00
2	-6.00	0.08	0.00
3	-4.00	0.08	0.00
4	-2.00	0.00	0.16
5	0.00	0.00	0.68
6	2.00	0.00	0.16
7	4.00	0.42	0.00
8	6.00	0.08	0.00
9	7; ∞	0.08	0.00

Figure 23: Example of Standardized Residual Histogram part

3.5.4 Galbraith Plot

The basic idea of the Galbraith plot or radial plot (Galbraith, 1988) is to run an unweighted regression of *z*-scores on the inverse of the standard error with the intercept constrained to zero (see Figure 24). This plot can be used to look for outliers in the effect sizes. The expectation is that 95% of the studies is within the area defined by the two (lighter coloured) confidence interval lines. *Meta-Essentials* gives a table with studies, a plot and a table with regression estimates (see Figure 24).

Study name	Inverse standard error	Z-value
aaaa	3.97	8.72
bbbb	4.83	8.69
cccc	3.74	7.10
dddd	7.02	14.40
eeee	4.91	0.25
ffff	4.68	-2.81
gggg	4.49	8.98
hhhh	4.83	8.69
iiii	4.47	1.79
jjjj	6.23	13.09
kkkk	4.74	-1.89
llll	4.96	-2.48



Regression estimate				
	Estimate	SE	CI LL	CI UL
Intercept (fixed at 0)	0.00			
Slope	1.15	0.06	1.02	1.28

Figure 24: Example of Galbraith Plot part of the Publication Bias Analysis sheet

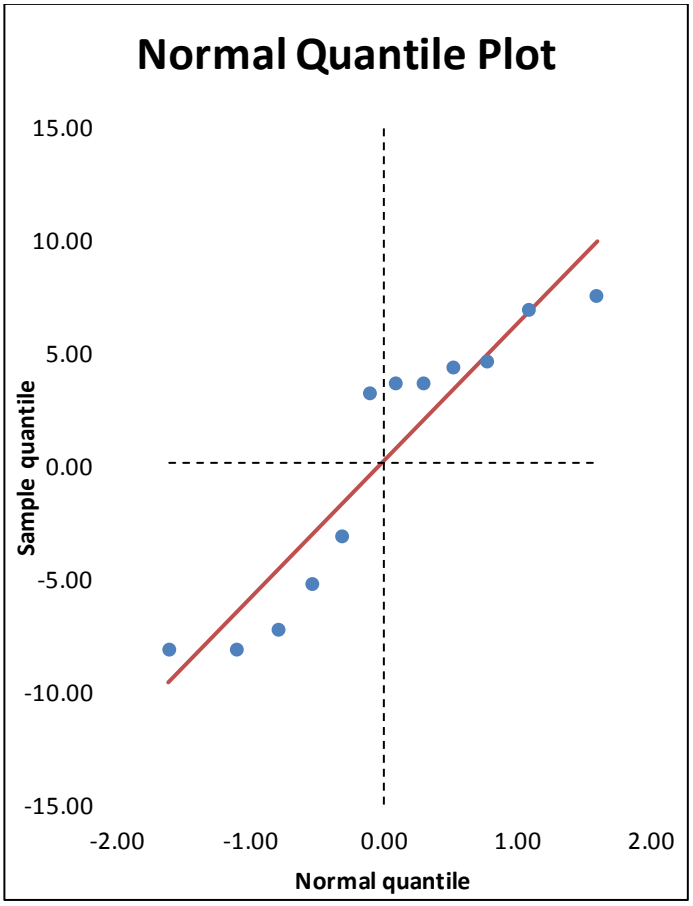
3.5.5 Normal Quantile Plot

Normal Quantile plots (or Q-Q-plots) are also used to assess the normality of data (Wang & Bushman, 1998). The expectation is that all data points are approximately on a straight line, which would indicate that the dispersion of the data follows a standard normal distribution.

This part in *Meta-Essentials* (see Figure 25) consists of four sections: a table with studies, a plot, regression estimates, and an input option for the calculation of sample quantiles. The table presents the study names, the estimated normal quantile and the sample quantile. The plot gives these normal and sample quantiles as well as a regression line through them.

With the input option, the user can choose to base the sample quantiles on either 'Standardized residuals' or '*Z*-scores' (see red rectangle in Figure 25).

Study name	Normal quantile	Sample quantile
aaaa	0.79	4.62
bbbb	0.10	3.69
cccc	-0.10	3.19
dddd	1.61	7.56
eeee	-0.53	-5.20
ffff	-1.10	-8.10
gggg	0.53	4.34
hhhh	0.31	3.69
iiii	-0.31	-3.08
jjjj	1.10	6.91
kkkk	-0.79	-7.22
llll	-1.61	-8.11



Regression estimate				
	Estimate	SE	CI LL	CI UL
Intercept	0.19	0.64	-1.21	1.60
Slope	6.06	0.71	4.49	7.64

Base sample quantiles on	Standardized residuals

Figure 25: Example of Normal Quantile Plot part of the Publication Bias Analysis sheet

3.5.6 Failsafe-N tests

The final part of the Publication Bias Analysis sheet contains several estimates of Failsafe numbers. To illustrate this, imagine that for any study, a number of other studies is not published. Assume that these additional studies have insignificant results, i.e. their effect sizes are essentially zero. Then, the failsafe number estimates the number of such additional studies that are required to turn the effect size from the included and additional studies combined insignificant, i.e. that the 'new' combined effect size is essentially zero.

3.5.6.1 Rosenthal

In order to calculate a Failsafe-N, first described by Rosenthal (1979), a test of combined significance is conducted. The failsafe number is the number of missing studies averaging a z-value of zero that should be added to make the combined effect size statistically insignificant (see Figure 26 for an example). The ad-hoc rule refers to the one by Rosenthal (1979) for deciding whether the number estimated is small (TRUE) or large (FALSE).

Rosenthal	
Overall Z-score	18.63
Failsafe-N	1527
Ad-hoc rule	FALSE

Figure 26: Example of Rosenthal's Failsafe-N of the Publication Bias Analysis sheet

3.5.6.2 Gleser & Olkin

Gleser and Olkin (1996) provide an estimate for the number of unpublished results (see Figure 27 for an example). It uses the assumption that the studies in the meta-analysis have the largest significance (i.e., smallest *p*-values) from a population of effect sizes. The size of the largest *p*-value in the meta-analysis determines the number of estimated unpublished studies. There is no method to assess whether this number is small or large, but a comparison could be made with the number of studies that actually are included in the meta-analysis.

Gleser & Olkin	
Failsafe-N	0

Figure 27: Example of Gleser and Olkin's Failsafe-N of the Publication Bias Analysis sheet

3.5.6.3 Orwin

Orwin (1983) uses a slightly different approach by looking at effect sizes rather than at *p*-values. For this method, the user sets a criterion value for the combined effect size. The user can set any value that would make the result of the meta-analysis arbitrary (ES_C) (see Figure 28 for an example). Secondly, the user sets the mean of the studies that are imputed (ES_{FS}). Then the failsafe number will give the number of studies with average effect size (ES_{FS}) that would reduce the combined effect to the criterion value (ES_C).

Orwin	
Criterion value ES_C	0.05
Mean fail safe studies ES_{FS}	0
Failsafe-N	265

Figure 28: Example of Orwin's Failsafe-N of the Publication Bias Analysis sheet

3.5.6.4 Fisher

The fourth and final failsafe number method provided by *Meta-Essentials* (proposed by Fisher, 1932) is also based on a test of the combined significance (see Figure 29 for an example). It is based on the sum of the natural logarithm of the *p*-values from the studies in the meta-analysis. The number can be tested with a Chi-Square distribution with degrees of freedom of two times the number of studies in the meta-analysis.

Fisher	
Failsafe-N	8549
p(Chi-square test)	0.000

Figure 29: Example of Fisher's Failsafe-N of the Publication Bias Analysis sheet

3.6 Calculations sheet

The Calculations sheet of *Meta-Essentials* contains all calculations underlying the output in the other sheets. It can be accessed by clicking on the regarding tab, as shown in Figure 17. It is a rather extensive sheet in which different parts are clearly indicated by a header. This sheet has no other function than documenting the intermediary outputs of an analysis, or equivalently, the transformations between input and output. Because reading this sheet is not necessary for running a

meta-analysis (or for other types of analysis in *Meta-Essentials*) and because column names are (hopefully) self-explanatory, this sheet will be discussed only very briefly in this manual.

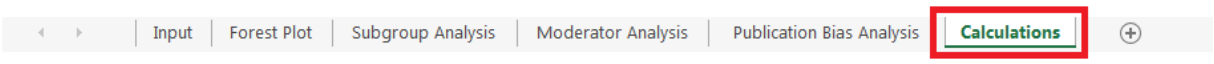


Figure 30: The tab to access the Publication Bias Analysis sheet of Meta-Essentials

3.6.1 Forest Plot

The first part contains the necessary calculations to construct the Forest Plot sheet (see Figure 31 for an example). The first two columns give ranks for the presentation functions 'Sort By' and 'Order' on the Input sheet. Effect sizes, variances, standard errors, the weights, in both fixed and random effects models, are provided along with the confidence interval limits. Finally, the relative weight the study receives in the model is given (based on the choice between fixed and random effects). The second table repeats the estimates of effects size as well as the lengths of the confidence interval bars for plotting purposes. On the right side the same is done for the combined effect size. Note that cells showing "#N/A" are meant to show these errors since it is the only way to let Microsoft Excel ignore them when making the plots, unfortunately.

Output #		Entry number	Study name	Effect size	Number of observations	Standard error	Weight (fixed)	Weight (random)	CI Lower limit	CI Upper Limit	Weight %	Residual
1	1	1	aaaa	2.20	100	0.25	15.73	0.73	1.70	2.70	8.22%	1.13
2	2	2	bbbb	1.80	130	0.21	23.33	0.74	1.39	2.21	8.35%	0.73
3	3	3	cccc	1.90	80	0.27	13.97	0.73	1.37	2.43	8.17%	0.83
4	4	4	dddd	2.05	300	0.14	49.33	0.75	1.77	2.33	8.49%	0.98
5	5	5	eeee	0.05	95	0.20	24.06	0.74	-0.35	0.45	8.35%	-1.02
6	6	6	ffff	-0.60	90	0.21	21.89	0.74	-1.02	-0.18	8.33%	-1.67
7	7	7	gggg	2.00	120	0.22	20.17	0.74	1.56	2.44	8.30%	0.93
8	8	8	hhhh	1.80	130	0.21	23.33	0.74	1.39	2.21	8.35%	0.73
9	9	9	iiii	0.40	80	0.22	19.98	0.74	-0.05	0.85	8.30%	-0.67
10	10	10	jjjj	2.10	240	0.16	38.84	0.75	1.78	2.42	8.45%	1.03
11	11	11	kkkk	-0.40	90	0.21	22.43	0.74	-0.82	0.02	8.33%	-1.47
12	12	12	llll	-0.50	100	0.20	24.61	0.74	-0.90	-0.10	8.36%	-1.57

ES Forest plot	CI Bar LL	CI Bar UL
2.20	0.50	0.50
1.80	0.41	0.41
1.90	0.53	0.53
2.05	0.28	0.28
0.05	0.40	0.40
-0.60	0.42	0.42
2.00	0.44	0.44
1.80	0.41	0.41
0.40	0.45	0.45
2.10	0.32	0.32
-0.40	0.42	0.42
-0.50	0.40	0.40

CES forest plot	
Display # CES	13
CI Bar width LL	0.74
CI Bar width UL	0.74
PI Bar width LL	2.62
PI Bar width UL	2.62
Size of bubble	0.08

Figure 31: Example of Forest Plot part of the Calculations sheet

3.6.2 Subgroup Analysis

The subgroup analysis section of the calculations sheet contains the necessary calculations to construct the Subgroup Analysis sheet. It begins with repeating the information from the input section (see Figure 32 for an example). The first section, to the left, gives information per study. The 'Display # studies' as well as the information in the second table of the following picture are for plotting purposes. The weights in a random model (if that was chosen in the Subgroup Analysis sheet) depend on subgroup estimates of heterogeneity, either separate per subgroup or pooled over subgroups, as specified in the Subgroup Analysis sheet.

Display # studies	Study name	Subgroup	Effect size	Standard error	Weight (fixed)	Weight	CI Lower limit	CI Upper Limit	Weight %	Residual	ES Forest plot	CI Bar LL	CI Bar UL
1	aaaa	AA	2.20	0.25	15.73	13.62	1.70	2.70	9.59%	0.21	2.20	0.50	0.50
2	bbbb	AA	1.80	0.21	23.33	18.97	1.39	2.21	13.36%	-0.19	1.80	0.41	0.41
3	cccc	AA	1.90	0.27	13.97	12.28	1.37	2.43	8.65%	-0.09	1.90	0.53	0.53
4	dddd	AA	2.05	0.14	49.33	33.22	1.77	2.33	23.39%	0.06	2.05	0.28	0.28
9	eeee	BB	0.05	0.20	24.06	19.46	-0.35	0.45	21.07%	0.27	0.05	0.40	0.40
10	ffff	BB	-0.60	0.21	21.89	18.01	-1.02	-0.18	19.50%	-0.38	-0.60	0.42	0.42
5	gggg	AA	2.00	0.22	20.17	16.83	1.56	2.44	11.85%	0.01	2.00	0.44	0.44
6	hhhh	AA	1.80	0.21	23.33	18.97	1.39	2.21	13.36%	-0.19	1.80	0.41	0.41
11	iiii	BB	0.40	0.22	19.98	16.70	-0.05	0.85	18.08%	0.62	0.40	0.45	0.45
7	jjjj	AA	2.10	0.16	38.84	28.11	1.78	2.42	19.79%	0.11	2.10	0.32	0.32
12	kkkk	BB	-0.40	0.21	22.43	18.38	-0.82	0.02	19.90%	-0.18	-0.40	0.42	0.42
13	llll	BB	-0.50	0.20	24.61	19.81	-0.90	-0.10	21.45%	-0.28	-0.50	0.40	0.40

Figure 32: Example of first part of Subgroup Analysis part of the Calculations sheet Subgroup Analysis

The second section refers to subgroups and starts with a display number for plotting purposes (see Figure 33 for an example). It gives the name of the subgroup, the subgroup number, and the number of studies in the subgroups followed by heterogeneity measures and subgroup combined effect sizes estimates with standard errors, confidence and prediction interval limits and finishes with weights for fixed and random effects models.

Display #	Subgroup	#	Studies in the subgroup	Q	p_Q	I^2	C	T^2	T	CES	SE_{CES}	N	CI LL	CI UL	CI bar width LL	CI bar width UL	PI LL	PI UL	PI bar width LL	PI bar width UL	Q random effects model	CES forrest plot	Weight % between subgroups	Fixed effects between subgroup weight	Random effects between subgroup weight	Weighted sum of squares	Residual
8	AA	1	7	3.14	0.791	0.00%	152.85	0.01	0.10	1.99	0.05	1100	1.88	2.10	0.11	0.11	1.77	2.21	0.22	0.22	2.53	1.99 #N/A #N/A #N/A	50.32%	336.63	0.41	0.50	1.10
14	BB	2	5	15.25	0.004	73.77%	90.26	0.01	0.10	-0.22	0.18	455	-0.58	0.14	0.36	0.36	-0.63	0.19	0.41	0.41	12.59	-0.22 #N/A #N/A #N/A #N/A #N/A #N/A #N/A	49.68%	29.35	0.41	0.50	-1.11

Figure 33: Example of second part of Subgroup Analysis part of the Calculations sheet

The third and final section of the Subgroup Analysis part of the Calculation sheet contains information for the combined effect size as well as heterogeneity measures (see Figure 34 for an example). Below these estimates the between and within subgroup weighting methods input options are given in text (for reference purposes).

Combined effect size	
Effect Size	0.89
SE	1.10
CI Lower Limit	-1.44
CI Upper Limit	3.22
PI Lower Limit	-3.14
PI Upper Limit	4.92

Total heterogeneity	
Q	362.77
p_Q	0.000
I^2	0.95
T^2	1.28
T	1.13

CES subgroup plot	
Display # CES	15
Display # CES 2	3
CI Bar width LL	2.33
CI Bar width UL	2.33
PI Bar width LL	4.03
PI Bar width UL	4.03
Size of buble	0.50

Heterogeneity between subgroups (random)	
$Q_{between}$	131.80
T^2	2.42

Between subgroup weighting methods
Fixed effects
Random effects

Within subgroup weighting methods
Fixed effects
Random effects (Tau separate for subgroups)
Random effects (Tau pooled over subgroups)

Figure 34: Example of third part of Subgroup Analysis part of the Calculations sheet

3.6.3 Moderator Analysis

This part of the Calculations sheet contains the necessary calculations for the Moderator Analysis sheet (see Figure 35 for an example). The first table repeats information from the input section ('Moderator' and 'Effect Size') for plotting purposes. The first table furthermore contains information from a fixed effects model, the second table from a random effects model and the third for the combined effect size and heterogeneity measures in a fixed effects model. Below the third table the regression line is given for plotting purposes.

Moderator	ES regression plot	ES-CES_f	Moderator-Weighted average moderator	$Weight_f$*(ES-Constant-Slope*Moderator)^2
15.00	2.20	1.05	-2.51	20.25
16.00	1.80	0.65	-1.51	11.43
13.00	1.90	0.75	-4.51	11.41
18.00	2.05	0.90	0.49	38.28
20.00	0.05	-1.10	2.49	33.98
14.00	-0.60	-1.75	-3.51	58.20
19.00	2.00	0.85	1.49	12.79
13.00	1.80	0.65	-4.51	15.08
19.00	0.40	-0.75	1.49	12.91
22.00	2.10	0.95	4.49	24.39
17.00	-0.40	-1.55	-0.51	52.82
18.00	-0.50	-1.65	0.49	68.56

Weight	ES -CES	Moderator-Weighted average moderator	Weight*(ES - Constant-Slope*Moderator)^2
0.66	1.13	-2.01	0.78
0.67	0.73	-1.01	0.34
0.66	0.83	-4.01	0.36
0.68	0.98	0.99	0.69
0.67	-1.02	2.99	0.60
0.67	-1.67	-3.01	2.02
0.67	0.93	1.99	0.64
0.67	0.73	-4.01	0.28
0.67	-0.67	1.99	0.26
0.68	1.03	4.99	0.89
0.67	-1.47	-0.01	1.44
0.67	-1.57	0.99	1.60

Fixed effects model	
Combined effect size	1.15
Weighted average moderator	17.51
Slope	0.03
Constant	0.55
$Q_{residual}$	360.10
T^2	1.45
Moderator k	12

Regression line	
x	y
11.70	1.19
24.20	0.90

Figure 35: Example of Moderator Analysis part of the Calculations sheet

3.6.4 Publication Bias Analysis

This part of the Calculations sheet contains the necessary calculations for the Publication Bias Analysis sheet and is divided a similar fashion as the regarding sheet. That is, the sheet is divided in sections for each procedure or statistic regarding publication bias analysis.

3.6.4.1 Funnel plot

The funnel plot section contains information for weighting, ranks for the trim and fill plot (discussed later) in the first table and gives estimates of the funnel lines, confidence and prediction interval bars of observed and adjusted combined effect sizes for plotting purposes in the rest of the tables (see Figure 36 for an example).

Weight (fixed)	Weight	Weight adjusted	Residual adjusted	Inverse SE	Z-value	Initial Ranks	Rank # Trim and Fill 1st	Rank # Trim and Fill 2nd	Rank # Trim and Fill 3rd	Effect size	SE
15.73	15.73	15.73	1.05	3.97	8.72	-8	-8	-7	-7	2.20	0.25
23.33	23.33	23.33	0.65	4.83	8.69	-1	-1	-1	-1	1.80	0.21
13.97	13.97	13.97	0.75	3.74	7.10	-3	-3	-3	-3	1.90	0.27
49.33	49.33	49.33	0.90	7.02	14.40	-6	-6	-5	-5	2.05	0.14
24.06	24.06	24.06	-1.10	4.91	0.25	9	9	9	9	0.05	0.20
21.89	21.89	21.89	-1.75	4.68	-2.81	12	12	12	12	-0.60	0.21
20.17	20.17	20.17	0.85	4.49	8.98	-5	-5	-4	-4	2.00	0.22
23.33	23.33	23.33	0.65	4.83	8.69	-1	-2	-2	-2	1.80	0.21
19.98	19.98	19.98	-0.75	4.47	1.79	4	4	8	8	0.40	0.22
38.84	38.84	38.84	0.95	6.23	13.09	-7	-7	-6	-6	2.10	0.16
22.43	22.43	22.43	-1.55	4.74	-1.89	10	10	10	10	-0.40	0.21
24.61	24.61	24.61	-1.65	4.96	-2.48	11	11	11	11	-0.50	0.20
										#N/A	#N/A
										#N/A	#N/A
										#N/A	#N/A
										#N/A	#N/A
										#N/A	#N/A

Funnel lines		
Diagnoals	x	y
Left	0.76	0.32
Middle	1.47	0.00
Right	2.17	0.32
Mid line	x	y
Lower	1.47	0.00
Upper	1.47	0.32

Funnel plot display	
CI Bar	0.13
PI Bar	2.52
Plot SE	0.29

Trim and Fill plot display	
CI Bar adjusted	0.12
PI Bar adjusted	2.90
Plot SE adjusted	0.32

Figure 36: Example of Funnel Plot part of the Calculations sheet

3.6.4.2 Trim and fill plot

The first table in the trim and fill plot section gives the differences between the study's effect size and the combined effect size (denoted by X_i), its absolute and the weight the study receives (see Figure 37 for an example). This is given three times because of the before mentioned three iterations. The ranks in the funnel plot section are derived by ranking the absolutes of X_i and

multiplying by minus one if X_i is negative (for pragmatic reasons these are included in the Funnel Plot part, shown before in Figure 36). The second part gives the combined effect size iterations with the combined effect size, heterogeneity and estimated number of missing studies per iteration.

Xi first	|Xi| first	Recalculated Weight first	Xi second	|Xi| second	Recalculated Weight second	Xi third	|Xi| third	Recalculated Weight third
-1.05	1.05	15.73	-0.73	0.73	15.73	-0.73	0.73	15.73
-0.65	0.65	23.33	-0.33	0.33	23.33	-0.33	0.33	23.33
-0.75	0.75	13.97	-0.43	0.43	13.97	-0.43	0.43	13.97
-0.90	0.90	49.33	-0.58	0.58	49.33	-0.58	0.58	49.33
1.10	1.10	24.06	1.42	1.42	24.06	1.42	1.42	24.06
1.75	1.75	21.89	2.07	2.07		2.07	2.07	
-0.85	0.85	20.17	-0.53	0.53	20.17	-0.53	0.53	20.17
-0.65	0.65	23.33	-0.33	0.33	23.33	-0.33	0.33	23.33
0.75	0.75	19.98	1.07	1.07	19.98	1.07	1.07	19.98
-0.95	0.95	38.84	-0.63	0.63	38.84	-0.63	0.63	38.84
1.55	1.55	22.43	1.87	1.87	22.43	1.87	1.87	22.43
1.65	1.65	24.61	1.97	1.97		1.97	1.97	

Combined Effect Size Iterations	
1st Trimmed combined	
Effect Size	1.47
Heterogeneity	
Q	203.57
T^2	0.87
Missing studies	2
2nd Trimmed combined	
Effect Size	1.47
Heterogeneity	
Q	203.57
T^2	0.87
Missing studies	2
3rd Trimmed combined	
Effect Size	1.47
Heterogeneity	
Q	203.57
T^2	0.87
Missing studies	2

Figure 37: Example of first and second part of Funnel Plot part of the Calculations sheet

The third part contains information for the imputed data points, the estimated effect size and standard error and repeats that information in the fourth table for plotting purposes (see Figure 38 for an example).

Imputed studies	Rank number	Effect size	SE	Weight (fixed)	Weight	Residual
1	12	3.53	0.21	21.89	21.89	2.07
2	11	3.43	0.20	24.61	24.61	1.97
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Imputed Study #	Effect size	SE
1	3.53	0.21
2	3.43	0.20
3	#N/A	#N/A
4	#N/A	#N/A
5	#N/A	#N/A
6	#N/A	#N/A
7	#N/A	#N/A
8	#N/A	#N/A
9	#N/A	#N/A
10	#N/A	#N/A
11	#N/A	#N/A
12	#N/A	#N/A

Figure 38: Example of third and fourth part of Trim and Fill part of the Calculations sheet

3.6.4.3 Egger regression

The calculations for the Egger regression are mostly executed directly on the Publication Bias Analysis sheet, except for some estimates needed for the calculations of the standard errors of the regression estimates (see Figure 39 for an example).

Inv SE - Av Inv SE	Error terms
-0.94	6.12
-0.08	3.54
-1.17	5.17
2.12	2.77
0.00	-5.13
-0.23	-7.52
-0.41	4.83
-0.08	3.54
-0.43	-2.31
1.33	3.80
-0.17	-6.77
0.06	-8.02

Figure 39: Example of Egger Regression part of the Calculations sheet

3.6.4.4 Begg & Mazumdar rank correlation test

For the Begg & Mazumdar rank correlation test, an adjusted effect size and variance are first derived, followed by their respective ranks, all denoted with a star (*) to indicate that they are adjusted estimates (see Figure 40 for an example). Under *x*, the count of concordant ranks is given and under *y*, the count of discordant ranks is given. The remainder of the calculations is executed directly on the Publication Bias Analysis sheet.

Begg Mazumdar ES*	Begg Mazumdar V*	Rank ES*	Rank V*	x	y
4.27	0.06	3	2	8	3
3.26	0.04	5	7	4	6
2.86	0.07	7	1	5	6
6.91	0.02	1	12	0	11
-5.64	0.04	9	9	7	4
-8.52	0.04	11	5	5	6
3.94	0.05	4	4	7	4
3.26	0.04	5	7	4	6
-3.48	0.05	8	3	6	5
6.34	0.02	2	11	0	11
-7.64	0.04	10	6	5	6
-8.56	0.04	12	10	9	2

Figure 40: Example of Begg & Mazumdar Rank Correlation part of the Calculations sheet

3.6.4.5 Standardized Residual Histogram

The calculations for the standardized residual histogram consist of one table below for the calculation of the width of the bins and a table on top with the lower, middle and upper values of the bins (see Figure 41 for an example).

Bin #	Lower	Middle	Upper
1		-8.00	-7.00
2	-7.00	-6.00	-5.00
3	-5.00	-4.00	-3.00
4	-3.00	-2.00	-1.00
5	-1.00	0.00	1.00
6	1.00	2.00	3.00
7	3.00	4.00	5.00
8	5.00	6.00	7.00
9	7.00	8.00	

Bin width	
Max-Min	8.11
Bin width	2.00

Figure 41: Example of Standardized Residual Histogram part of the Calculations sheet

3.6.4.6 Galbraith plot

For the Galbraith plot, the calculations section contains the inverse standard error and z-score for plotting purposes (see Figure 42 for an example). The second table contains information for the regression lines in the plot.

Inverse SE	Z-score
3.97	8.72
4.83	8.69
3.74	7.10
7.02	14.40
4.91	0.25
4.68	-2.81
4.49	8.98
4.83	8.69
4.47	1.79
6.23	13.09
4.74	-1.89
4.96	-2.48

Regression lines		
Middle	x	y
Constant	0.00	0.00
Max	7.02	8.09
Lower	x	y
Constant	0.00	-2.20
Max	7.02	5.89
Upper	x	y
Constant	0.00	2.20
Max	7.02	10.29

Figure 42: Example of Galbraith Plot part of the Calculations sheet

3.6.4.7 Normal Quantile Plot

The calculations for the normal quantile plot contain information on the ranks, the normal and sample quantile for plotting purposes and some information for the calculation of the standard error

of the regression estimates (see Figure 43 for an example). The second table is used for plotting the regression line.

Sample rank	Quantile	Normal quantile plot	Sample quantile plot	Norm Quant - Av Norm Quant	Error Terms
10	0.78	0.79	4.62	0.79	-0.33
7	0.54	0.10	3.69	0.10	2.88
6	0.46	-0.10	3.19	-0.10	3.62
12	0.95	1.61	7.56	1.61	-2.37
4	0.30	-0.53	-5.20	-0.53	-2.16
2	0.14	-1.10	-8.10	-1.10	-1.60
9	0.70	0.53	4.34	0.53	0.92
8	0.62	0.31	3.69	0.31	1.62
5	0.38	-0.31	-3.08	-0.31	-1.40
11	0.86	1.10	6.91	1.10	0.03
3	0.22	-0.79	-7.22	-0.79	-2.65
1	0.05	-1.61	-8.11	-1.61	1.44

Regression line		
Line	x	y
Lower	-1.61	-9.55
Upper	1.61	9.94
Horizontal	x	y
Left	-1.61	0.19
Right	1.61	0.19

Figure 43: Example of Normal Quantile Plot part of the Calculations sheet

3.6.4.8 Failsafe-N tests

For the Failsafe numbers, the *z*-score, its *p*-value and a *log*-value of the *p*-value are given (see Figure 44 for an example). Note that because Excel cannot cope with more than 15 digits in its calculations 'under the hood', it will round the very small *p*-values to zero. Therefore, the natural logarithm of that value would give an error since the natural logarithm of zero is undefined. To overcome this problem *Meta-Essentials* automatically replaces *p*-values of zero with 10^{-306}, which natural logarithmic is -704.59, shown in several instances in the example.

Z-score	p-value	LN (p-value)
8.72	0.00	-704.59
8.69	0.00	-704.59
7.10	0.00	-28.11
14.40	0.00	-704.59
0.25	0.40	-0.91
-2.81	0.00	-5.99
8.98	0.00	-704.59
8.69	0.00	-704.59
1.79	0.04	-3.30
13.09	0.00	-704.59
-1.89	0.03	-3.54
-2.48	0.01	-5.03

Figure 44: Example of Failsafe-N part of the Calculations sheet

3.7 Statistical procedures

Meta-Essentials applies the inverse variance weighting method with, in the random effects model, an additive between-studies variance component based on the DerSimonian-Laird estimator

(DerSimonian & Laird, 1986). Note that in Workbook 2 '*Differences between independent groups - binary data.xlsx*' you can choose between three weighting methods. The confidence intervals are estimated using the weighted variance method for random effects models, see Sánchez-Meca and Marín-Martínez (2008). This means that the standard error, and thus the confidence and prediction intervals, of the combined effect size calculated by *Meta-Essentials* might be different from one calculated by another meta-analysis program, but has been shown to be better.

Specifically for the moderator analysis, the *Q*-statistics in *Meta-Essentials* depend on whether the fixed or random effects model is chosen, in contrast to some other tools for meta-analysis that report *Q*-statistics that are based on the fixed effects model only, even if the random effects model is selected. If the user is interested in the *Q*-statistics that are based on the fixed effects model, the user can temporarily set the meta-analysis model to fixed effects, or look it up on the calculations sheet where *Q* reported at the heterogeneity part corresponds to the $Q_{residual}$ in a fixed effects model. Higgins and Thompson (2002) provide guidance on the execution of a regression analysis and its interpretation. As one of their most important remarks, they note that the applicability of regression analysis might be low due to limited data-availability.

For a discussion of the methods applied in the Publication Bias Analysis sheet, their application and how they should be interpreted, see Sterne, Gavaghanb, and Egger (2000) and Anzures-Cabrera and Higgins (2010). Specifically for the Trim and Fill plot, *Meta-essentials* uses an iterative procedure for trimming the set of studies from the right (or left), re-estimate a combined effect size, and finally filling the plot with symmetric results on the other side of the mean. *Meta-Essentials* runs three iterations of the procedure, which is shown to be sufficient for many real-life cases (Duval & Tweedie, 2000a).

4 Specific features of individual workbooks

The basic features of *Meta-Essentials* have been discussed above. The user will be able to navigate through the different worksheets of a *Meta-Essentials* workbook. However, each of these workbooks has unique features that must be understood before they can be properly used. The features will be discussed in this section.

4.1 Workbook 2 *'Differences between independent groups - binary data.xlsx'*

4.1.1 Input sheet

The required input for this workbook is not a point estimate with a standard error (such as in Workbook 1). Instead, the user must enter either the number of cases with either outcome in each group (see cells a, b, c, and d in the two-by-two table on the right side of Figure 45). Or any other combination of information that makes it possible to calculate these four numbers. In practice this means that the user must fill at least four of the six cells in this two-by-two table. Each of the rows in Figure 45 represents a study with sufficient information according to this principle.

It is a unique feature of this workbook that an effect size (e.g., an odds ratio by) can be converted into another one (e.g., a risk difference). It is not possible to insert any one of these effect sizes directly in this workbook, because this conversion is not possible without the full information from the 2x2 table.

#	Study name	Include study	a	b	c	d	n_1	n_2	Sufficient data	Subgroup	Moderator
1	aaaa	Yes	10		4		50	50	Yes	AA	15
2	bbbb	Yes	20		12		65	65	Yes	AA	16
3	cccc	Yes	15	25	18	22			Yes	AA	13
4	dddd	Yes	30			130	150	150	Yes	AA	18
5	eeee	Yes	18			36	48	47	Yes	BB	20
6	ffff	Yes	17	28	10	35			Yes	BB	14
7	gggg	Yes		51	10		60	60	Yes	AA	19
8	hhhh	Yes		50	6		65	65	Yes	AA	13
9	iiii	Yes	5	35	4	36			Yes	BB	19
10	jjjj	Yes		110		115	120	120	Yes	AA	22
11	kkkk	Yes		37		32	45	45	Yes	BB	17
12	llll	Yes	8	42	5	45			Yes	BB	18

	Outcome 1	Outcome 2	Total
Group 1	a	b	n1
Group 2	c	d	n2

Figure 45: Input sheet of Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.2 Forest Plot sheet

A unique feature of this workbook is an additional forest plot that presents the effect sizes on a logarithmic scale, see red rectangle in Figure 46 for an example. Note that the lowest value on the x-axis shows '0.13' instead of '0.125' because of rounding. This makes it easier to interpret the results of the meta-analysis when the odds ratio or risk ratio is selected as the effect size measure. It is recommended to always use the logarithmic forest plot for the presentation of a meta-analysis of odds ratios or risk ratios and to use the 'normal' forest plot for risk differences only.

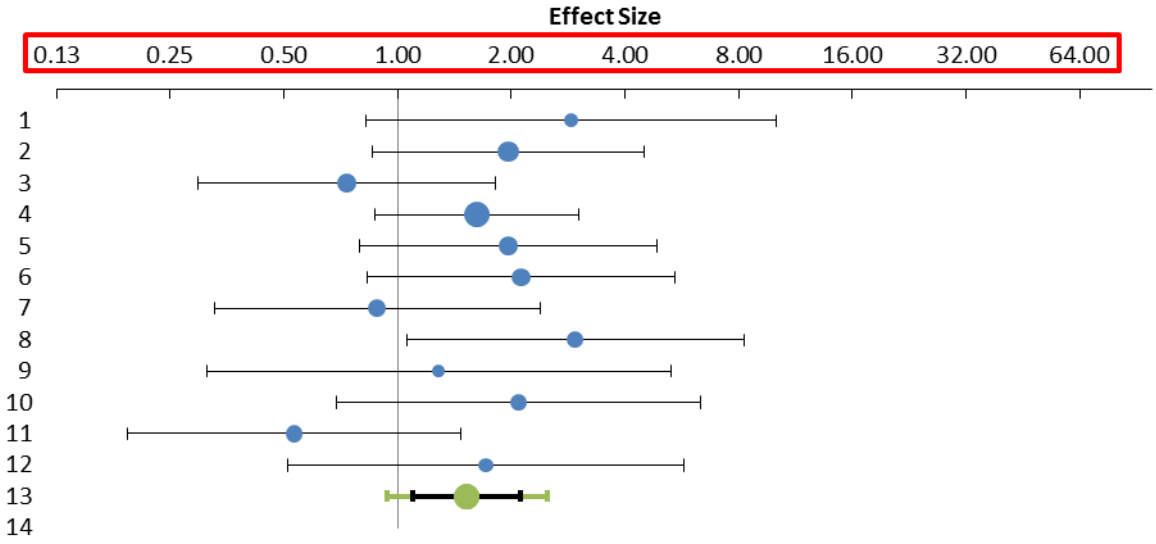


Figure 46: Logarithmic forest plot in Forest Plot sheet of Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.2.1 Weighting methods

The user can choose between three weighting methods: the standard inverse variance method, the Mantel-Haenszel method (Mantel & Haenszel, 1959) or the Peto-Odds method (Peto et al., 1977, p. 31).

4.1.2.2 Meta-analysis model and presentation effect size

From a statistical perspective, meta-analysing (Log) Odds Ratios is preferable because the Odds Ratio is less prone to heterogeneity (compared to Risk Difference in particular). On the down side, however, the Odds Ratio is rather hard to interpret.

In this workbook the user can select an effect size for the meta-analysis model (i.e. the effect size measure used in the calculations) and another one for presentation in the forest plot. All calculations can be inspected on the Calculations sheet. Note that conversion is performed only from Odds Ratio to Risk Ratio or Risk Difference ('downstream'), not the other way around, because there is no use for the opposite direction.

For the inverse variance weighting method, the user can also choose between using the Odds Ratio, Risk Ratio and Risk Difference (for both the model and the presentation). If you choose the Odds Ratio or Risk Ratio for the model, the meta-analysis will actually be run in Log Odds Ratio and Log Risk Ratio respectively. For the Peto weighting method, a slightly different Odds Ratio is available, called the Peto Odds Ratio, whereas all other options are available as well.

Note that a weighting method must be chosen **before** the effect size measure, because not all options (for effect size measure) are available for all weighting methods. The user is informed about the 'validity' ('Yes' or 'No') of a combination that is selected in the 'Valid options chosen' row (see Figure 47).

Meta-analysis model options	
Weighting method	Inverse variance
Model Effect Size Measure	Risk Ratio
Presentation Effect Size Measure	Risk Ratio
Valid options chosen	Yes

Presentation	
Sort by	Entry number
Order	Ascending

Figure 47: Example of additional selection options on the Forest Plot sheet of Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.2.3 Statistical procedures

Some non-standard solutions are used in this workbook for conversion of statistics for Odds Ratio to statistics for Risk Difference, particularly for the standard error (which affects the calculation of the confidence and prediction interval). The basic premise of this procedure is that the statistical significance of the various statistics is equal. See the working paper on the website for this method by Van Rhee & Suurmond (2015).

Note that not all the heterogeneity measures are scale-free and that they are based on the effect size measure of the model, not the effect size measure of the presentation. This means that the scale of the heterogeneity measures depends on the choice of the effect size measure in the model.

4.1.3 Subgroup Analysis sheet

In the Subgroup Analysis it is not possible to make separate choices of effect size measure for the model and the presentation.

Meta-analysis model	
Weighting Method	Inverse Variance
Effect Size Measure	Odds Ratio
Valid options chosen	Yes
Between subgroup weighting	Random effects
Within subgroup weighting	Random effects (Tau pooled over subgroups)
Confidence level	95%

Figure 48: Options for Subgroup Analysis in Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.4 Moderator Analysis sheet

The moderator regression for binary data can be run in Log Odds Ratio, Log Risk Ratio or Risk Difference. The logarithmic values of the Odds Ratio and Risk Ratio are used instead of the 'normal' values because they tend to normality faster (see Figure 49).

Meta-analysis model	
Weighting method	Inverse Variance
Effect Size Measure	Log Risk Ratio
Valid options chosen	Yes
Model	Random effects
Confidence level	95%

Figure 49: Options for Moderator Analysis in Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.5 Publication Bias Analysis sheet

Procedures for assessing publication bias for binary data can be run in Log Odds Ratio, Log Risk Ratio or Risk Difference (see Figure 50).

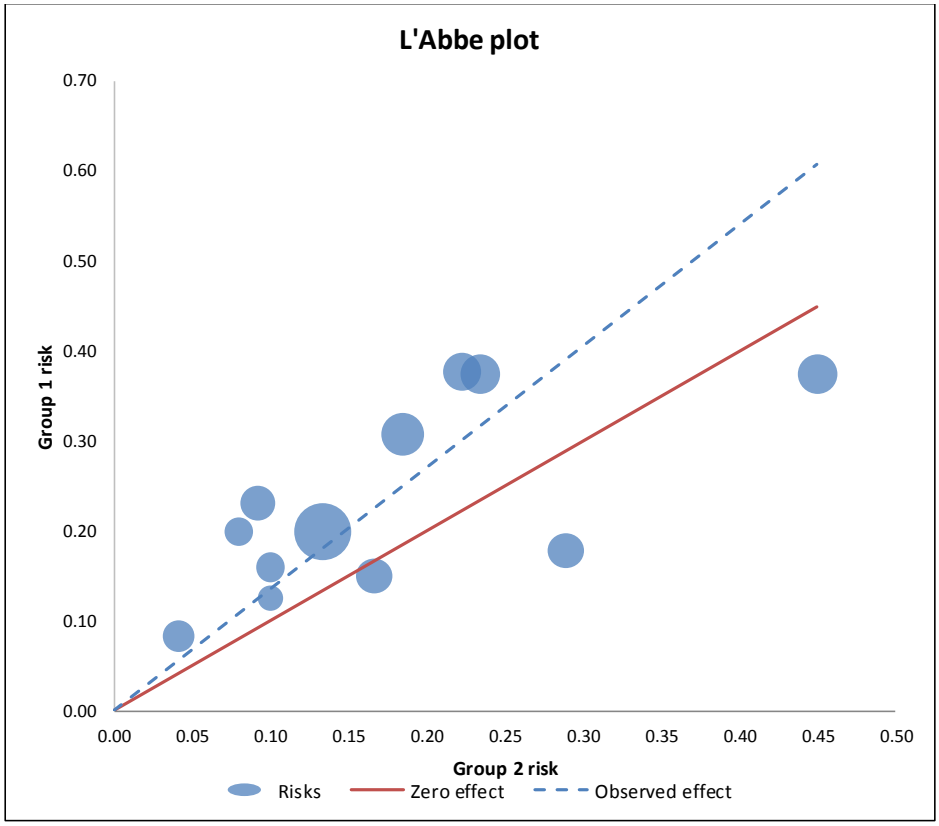
Meta-analysis model	
Weighting method	Inverse Variance
Effect Size Measure	Log Risk Ratio
Valid options chosen	Yes
Model	Fixed effects
Confidence level	95%

Figure 50: Options for Publication Bias Analysis in Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.5.1 L'Abbé plot

One additional plot is provided for binary data, the L'Abbé plot (L'Abbé, Detsky, & O'Rourke, 1987) (see Figure 51). This plot gives the Group 2 (e.g., control) risk on the x-axis and the Group 1 (e.g., treatment) risk on the y-axis. A reference line of zero effect (the diagonal) is provided in red along with a blue dotted line that gives the ratio between the risks of group 2 and group 1 (the combined Risk Ratio). The size of the point estimates (blue dots) corresponds to the study weights. The study weights depend on the chosen model (fixed versus random effects) and on the chosen weighting method.

Study name	Group 2 risk	Group 1 risk
aaaa	0.08	0.20
bbbb	0.18	0.31
cccc	0.45	0.38
dddd	0.13	0.20
eeee	0.23	0.38
ffff	0.22	0.38
gggg	0.17	0.15
hhhh	0.09	0.23
iiii	0.10	0.13
jjjj	0.04	0.08
kkkk	0.29	0.18
llll	0.10	0.16



Combined effect size	
Fixed effects model	
Risk Ratio	1.35

Figure 51: L'Abbé Plot on the Publication Bias Analysis sheet of Workbook 2 'Differences between independent groups - binary data.xlsx'

4.1.6 Calculations sheet

The calculations sheet for binary data begins with a repetition of the cell counts and the "Add 0.5" asks whether any of the cells has a count of zero, in which case .5 should be added to all the cell counts because the effect sizes are not calculable otherwise. In this tab, you will see additional columns with log effect sizes for calculation purposes. Two additional headers (and thus chapters of the tab) are provided: 'Effect Sizes' and 'Weighting Methods'. In Effect Sizes, four parts describing the calculations for different effect sizes are given: odds ratio, Peto odds ratio, risk difference and risk ratio (see Figure 52 for an example). In Weighting Methods the three weighting methods are given (Inverse Variance, Mantel-Haenszel and Peto) (see Figure 53 for an example) along with some information for the conversion of one effect size measure into the other (see Figure 54 for an example).

Odds Ratio					
	OddsRatio	LogOddsRatio	$SE_{LogOddsRatio}$	CI $LL_{OddsRatio}$	CI $UL_{OddsRatio}$
	2.88	1.06	0.63	0.82	10.03
	1.96	0.67	0.42	0.86	4.49
	0.73	-0.31	0.46	0.30	1.82
	1.63	0.49	0.32	0.87	3.02
	1.96	0.67	0.46	0.79	4.85
	2.13	0.75	0.47	0.83	5.43
	0.88	-0.13	0.50	0.33	2.38
	2.95	1.08	0.52	1.05	8.25
	1.29	0.25	0.71	0.31	5.30
	2.09	0.74	0.56	0.69	6.35
	0.53	-0.63	0.51	0.19	1.47
	1.71	0.54	0.61	0.51	5.74

Peto Odds Ratio				
	PetoOdds Ratio	$SE_{LogPetoOddsRatio}$	CI $LL_{PetoOddsRatio}$	CI $UL_{PetoOddsRatio}$
	2.68	0.57	0.86	8.37
	1.93	0.41	0.87	4.31
	0.74	0.45	0.30	1.81
	1.61	0.31	0.88	2.97
	1.93	0.44	0.80	4.65
	2.08	0.46	0.84	5.16
	0.88	0.50	0.33	2.37
	2.76	0.47	1.08	7.06
	1.28	0.70	0.32	5.19
	2.03	0.53	0.71	5.79
	0.54	0.50	0.20	1.45
	1.69	0.59	0.52	5.47

Risk Difference				
	Risk Difference	$SERisk_{Difference}$	CI $LL_{RiskDifference}$	CI $UL_{RiskDifference}$
	0.12	0.07	-0.02	0.26
	0.12	0.07	-0.02	0.27
	-0.08	0.11	-0.29	0.14
	0.07	0.04	-0.02	0.15
	0.14	0.09	-0.04	0.33
	0.16	0.10	-0.03	0.34
	-0.02	0.07	-0.15	0.12
	0.14	0.06	0.01	0.26
	0.03	0.07	-0.12	0.17
	0.04	0.03	-0.02	0.10
	-0.11	0.09	-0.29	0.06
	0.06	0.07	-0.07	0.19

Risk Ratio					
	Risk Ratio	LogRiskRatio	$SE_{LogRiskRatio}$	CI $LL_{RiskRatio}$	CI $UL_{RiskRatio}$
	2.50	0.92	0.56	0.83	7.55
	1.67	0.51	0.32	0.88	3.14
	0.83	-0.18	0.27	0.49	1.42
	1.50	0.41	0.26	0.89	2.52
	1.60	0.47	0.32	0.84	3.04
	1.70	0.53	0.34	0.87	3.33
	0.90	-0.11	0.42	0.39	2.07
	2.50	0.92	0.45	1.03	6.09
	1.25	0.22	0.63	0.35	4.40
	2.00	0.69	0.53	0.70	5.71
	0.62	-0.49	0.40	0.28	1.35
	1.60	0.47	0.53	0.55	4.62

Figure 52 Example of Effect Sizes part of Calculations tab of Workbook 2 'Differences between independent groups - binary data.xlsx'

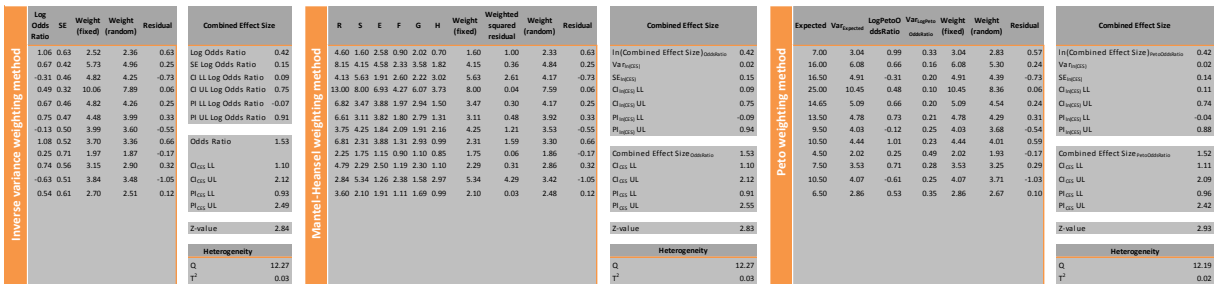


Figure 53 Example of Weighting Method part of Calculations tab of Workbook 2 'Differences between independent groups - binary data.xlsx'

Control group risk
0.08
0.18
0.45
0.13
0.23
0.22
0.17
0.09
0.10
0.04
0.29
0.10

Odds Ratio

	Inverse variance	Mantel-Haenszel	Peto
CES	1.53	1.53	#N/A
CI LL	1.10	1.10	
CI UL	2.12	2.12	
PI LL	0.93	0.91	
PI UL	2.49	2.55	

Risk Ratio

	Inverse variance	Mantel-Haenszel	Peto
CES	1.41	1.41	#N/A
CI LL	1.08	1.08	
CI UL	1.81	1.81	
PI LL	0.94	0.92	
PI UL	2.03	2.07	

Risk Difference

	Inverse variance	Mantel-Haenszel	Peto
CES	0.06	0.06	#N/A
SECES	0.02	0.02	
CI LL	0.01	0.01	
CI UL	0.11	0.11	
PI LL	-0.01	-0.01	
PI UL	0.13	0.14	

Figure 54: Example of Conversion to Other Effect Size Measures part of Calculations tab of Workbook 2 'Differences between independent groups - binary data.xlsx'

4.2 Workbooks 3 *'Differences between independent groups - continuous data.xlsx'* and 4 *'Differences between dependent groups - continuous data.xlsx'*

4.2.1 Input sheet

Workbooks 3 and 4 have a rather large number of different input formats, see Figure 55 for Workbook 3 and Figure 56 for Workbook 4. Hence, an important feature of these workbooks is that it they function as effect size generators. For instance, the user can insert raw group data (means,

standard deviations and sample sizes) or tests of differences (t-value, F-value) or already calculated effect sizes (Cohen's *d*, Hedges' *g*).

#	Study name	Include study	M_1	M_2	M_2-M_1	S_1	S_2	S_{pooled}	n_1	n_2	t-value	F-value	Cohen's d	Hedges' g	Sufficient data	Subgroup	Moderator
1	aaaa	Yes	10.00	8.00		1.00	1.20		50	50					Yes	AA	15
2	bbbb	Yes	11.00	8.00				1.20	65	65					Yes	AA	16
3	cccc	Yes			0.02	0.70	0.50		40	40					Yes	AA	13
4	dddd	Yes			-0.70			0.30	150	150					Yes	AA	18
5	eeee	Yes							48	47	-1.60				Yes	BB	20
6	ffff	Yes							45	45	-0.30				Yes	BB	14
7	gggg	Yes							60	60		0.50			Yes	AA	19
8	hhhh	Yes							65	65		0.70			Yes	AA	13
9	iiii	Yes							40	40				0.40	Yes	BB	19
10	jjjj	Yes							120	120				2.10	Yes	AA	22
11	kkkk	Yes							45	45			-0.40		Yes	BB	17
12	llll	Yes							50	47			-0.50		Yes	BB	18

Figure 55: Input sheet of Workbook 3 'Differences between independent groups - continuous data.xlsx'

#	Study name	Include study?	M_1	M_2	M_2-M_1	S_1	S_2	S_{diff}	N	r	t-value	F-value	Cohen's d	Hedges' g	Sufficient data	Subgroup	Moderator
1	aaaa	Yes	10.00	8.00		1.00	1.20		100	0.45					Yes	AA	15
2	bbbb	Yes	11.00	8.00				1.20	130	0.50					Yes	AA	16
3	cccc	Yes			0.02	0.70	0.50		80	0.47					Yes	AA	13
4	dddd	Yes			-0.70			0.30	300	0.51					Yes	AA	18
5	eeee	Yes							95	0.59	-1.60				Yes	BB	20
6	ffff	Yes							90	0.52	-0.30				Yes	BB	14
7	gggg	Yes							120	0.46		0.50			Yes	AA	19
8	hhhh	Yes							130	0.50		0.70			Yes	AA	13
9	iiii	Yes							80	0.52				0.40	Yes	BB	19
10	jjjj	Yes							240	0.48				2.10	Yes	AA	22
11	kkkk	Yes							90	0.41			-0.40		Yes	BB	17
12	llll	Yes							97	0.53			-0.50		Yes	BB	18

Figure 56: Input sheet of Workbook 4 'Differences between dependent groups - continuous data.xlsx'

Note the difference between the columns in the middle parts of these two figures which represents the difference in study design.

4.2.1.1 *Sufficient data*

Possible sufficient options are, amongst others (studies mentioned refer to Figure 55, Workbook 3):

- Means, standard deviations, and sample sizes for both groups:
  - M_1, M_2, S_1, S_2, n_1, and n_2; as in study *aaaa*;
- Means for both groups, the pooled standard deviation, and sample sizes for both groups:
  - M_1, M_2, S_{pooled}, n_1, n_2; study *bbbb*;
- The difference in means, and the standard deviations and sample sizes of both groups:
  - M_2-M_1, S_1, S_2, n_1 and n_2; study *cccc;*
- The difference in means, the pooled standard deviation, and sample sizes:
  - M_2-M_1, S_{pooled}, n_1 and n_2; study *dddd*;
- *t*-value and sample sizes:
  - *t*-value, n_1 and n_2; study *eeee*;
- *F*-value and sample sizes:
  - *F*-value, n_1 and n_2; study *gggg*;
- One of the effect sizes directly along with sample sizes:
  - Cohen's *d* OR Hedges' *g* with n_1 and n_2; studies *kkkk* and *iiii* respectively.

Note that in each option the sample sizes of both groups are required input. As a comparison between Figure 55 and Figure 56 shows, exactly the same input options are available in Workbook 4,

which is used when the effect size is a difference between two measurements in the same group, e.g., a 'pre-test' and a 'post-test'. Sample size is also required in this workbook (of only one group by definition) as is the correlation coefficient (*r*) describing the association between pairs of observations in the regarding study. However, since this correlation is often not reported and cannot be derived from other provided statistics, "the researcher will need to use data from other sources to estimate this correlation. If the correlation is not known precisely, one could work with a range of plausible correlations and use a sensitivity analysis to see how these affect the results" (Borenstein, 2009, pp. 227-228).

If more than sufficient information is entered, *Meta-Essentials* will automatically use the 'simplest' option: effect sizes first (where *g* is preferred over *d*), than means with standard errors, and finally *t*-values and *F*-values. Effect sizes will automatically be calculated as standardized mean differences. On the output sheets, the user can select either 'Cohen's *d*' or 'Hedges' *g*' as effect size measure.

4.2.2 Effect size measures

Cohen's *d* and Hedges' *g* are both standardized mean differences. Cohen's *d* was first developed by Cohen (1969) and then Hedges (1981) found a bias, particularly present in case of small sample sizes. It is now customary to correct for this bias, but some still refer to it as Cohen's *d* while Hedges' *g* would be a clearer name for it. Others (such as Cumming, 2012) refer to the latter as $d_{unbiased}$. In *Meta-Essentials*, Cohen's *d* refers to the standardized mean difference as proposed by Cohen and Hedges' *g* refers to the bias-adjusted standardized mean difference as proposed by Hedges.

4.3 Workbook 5 *'Correlational data.xlsx'*

4.3.1 Fisher's transformation

The main difference between this workbook and the workbooks discussed so far is the use of a so-called Fisher's *r*-to-*z* transformation (Fisher, 1921), which will automatically be applied because the transformed correlation (*z*) will faster tend to normality. For this transformed correlation, a standard error is estimated based on the number of subjects, the sample size.

4.3.2 Input sheet

Required input in this workbook is only (a) the correlation coefficient and (b) the sample size (see Figure 57). The meta-analysis is run with the Fisher-transformed values, which are transformed back into 'normal' correlation coefficients for presentation. The subscript *z* is used throughout this workbook to indicate transformed values. Please note that a correlation coefficient is equal to the standardized bivariate regression coefficient.

#	Study name	Include study	Correlation	Number of subjects	Sufficient data	Subgroup	Moderator
1	aaaa	Yes	0.98	100	Yes	AA	15.00
2	bbbb	Yes	0.95	130	Yes	AA	16.00
3	cccc	Yes	0.96	80	Yes	AA	13.00
4	dddd	Yes	0.97	300	Yes	AA	18.00
5	eeee	Yes	0.05	95	Yes	BB	20.00
6	ffff	Yes	-0.54	90	Yes	BB	14.00
7	gggg	Yes	0.96	120	Yes	AA	19.00
8	hhhh	Yes	0.95	130	Yes	AA	13.00
9	iiii	Yes	0.38	80	Yes	BB	19.00
10	jjjj	Yes	0.97	240	Yes	AA	22.00
11	kkkk	Yes	-0.38	90	Yes	BB	17.00
12	llll	Yes	-0.46	100	Yes	BB	18.00

Required data

Figure 57: Input sheet of Workbook 5 'Correlational data.xlsx'

4.3.3 Forest Plot sheet

With the 'Sort By' function, the user can additionally choose from options that include Fisher-transformed values, such as for the effect size, correlation coefficient, and variance, see Figure 58 for an example; they are indicated with (z). Its values are then automatically displayed in column J (but not used in the plot or in the table for the combined effect size).

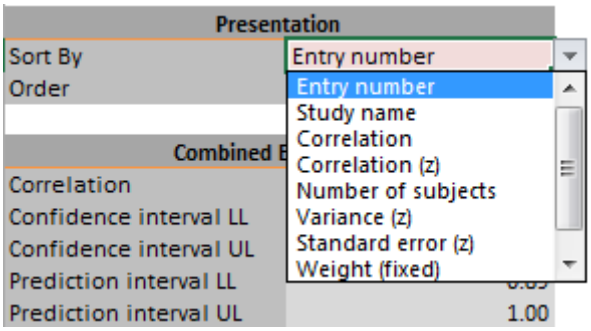


Figure 58: Example of 'Sort By' function on Input sheet of Workbook 5 'Correlational data.xlsx'

4.3.4 Moderator Analysis sheet

For the moderator analysis, Fisher's transformed correlation coefficients are used and displayed. This is a difference with some other sheets, where after the necessary computations the Fisher's transformed correlation coefficients are conversed back for presentation into 'normal' correlation coefficients.

4.3.5 Publication Bias Analysis sheet

For the publication bias analysis, Fisher's transformed correlation coefficients are used and displayed. This is a difference with some other sheets, where after the necessary computations the Fisher's transformed correlation coefficients are conversed back for presentation into 'normal' correlation coefficients.

4.4 Workbooks 6 *'Partial correlational data.xlsx'* and *7 'Semi-partial correlational data.xlsx'*

Both partial and semi-partial correlations are used to compare results of studies that have used different regression models (Aloë & Becker, 2012; Aloë, 2014). Although partial and semi-partial correlations have the same scale and statistical characteristics as zero-order correlation, it is

recommended not to mix these three types of correlation because they are *essentially different effect size measures*. For a brief description these effect size measures see the section in which we guide you in selecting the appropriate workbook.

4.4.1 Fisher's transformation

In every worksheet of Workbook 6, the user can choose to apply Fisher's transformation. Note that, as yet, the distributional behaviours of partial correlations and of Fisher's transformed values are not well known (e.g., Aloë, 2014, p. 48). It is recommended to run both analyses and compare the results.

4.4.2 Input sheet

There are various input options Workbooks 6 and 7 (see Figure 59 and Figure 60). The user can either insert pre-calculated (semi-)partial correlations or can choose to let the Workbook calculate them. In the latter case, the three main input formats in Workbook 6 are:

- *t*-value, number of predictors, and number of observations (study *dddd*).
- Beta, standard error (of Beta), number of predictors, and number of observations (study *gggg*).
- Partial correlation, number of predictors, and number of observations (study *jjjj*).
- Partial correlation, standard error (of partial correlation), and number of observations (see study *aaaa* in Figure 31). Please note that Fisher's transformation is not possible with this input (as indicated in the 'Sufficient data' column.

In Workbook 7, the possible input formats are similar to that of Workbook 6, however, providing the *R*-squared is mandatory for all input options except when providing the semi-partial correlation, the standard error (of the semi-partial correlation), and the number of observations.

#	Study name	Include study	Partial correlation	SE of Partial correlation	Beta	SE of Beta	t-value	Number of predictors in model	Number of observations	Sufficient data		Subgroup	Moderator
1	aaaa	Yes	0.40	0.10					100	Yes	Insufficient data for Fisher's r-to-z transformation	AA	15
2	bbbb	Yes	0.30	0.08					130	Yes	Insufficient data for Fisher's r-to-z transformation	AA	16
3	cccc	Yes	0.02	0.20					80	Yes	Insufficient data for Fisher's r-to-z transformation	AA	13
4	dddd	Yes					2.10	6	300	Yes		AA	18
5	eeee	Yes					-1.80	6	95	Yes		BB	20
6	ffff	Yes					-0.50	3	90	Yes		BB	14
7	gggg	Yes			0.20	0.05		7	120	Yes		AA	19
8	hhhh	Yes			0.22	0.04		8	130	Yes		AA	13
9	iiii	Yes			-0.05	0.11		4	80	Yes		BB	19
10	jjjj	Yes	-0.15					10	240	Yes		AA	22
11	kkkk	Yes	0.03					8	90	Yes		BB	17
12	llll	Yes	0.05					5	100	Yes		BB	18

Figure 59: Input in Workbook 6 'Partial correlational data.xlsx'

#	Study name	Include study?	Semi-partial correlation	SE of Semi-partial correlation	Beta	SE of Beta	t-value	R-squared	Number of predictors in model	Number of observations	Sufficient data	Subgroup	Moderator
1	aaaa	Yes	0.40	0.10						100	Yes	AA	15
2	bbbb	Yes	0.30	0.08						130	Yes	AA	16
3	cccc	Yes	0.02	0.20						80	Yes	AA	13
4	dddd	Yes					2.10	0.07	6	300	Yes	AA	18
5	eeee	Yes					-1.80	0.11	6	95	Yes	BB	20
6	ffff	Yes					-0.50	0.18	3	90	Yes	BB	14
7	gggg	Yes			0.20	0.05		0.06	7	120	Yes	AA	19
8	hhhh	Yes			0.22	0.04		0.08	8	130	Yes	AA	13
9	iiii	Yes			-0.05	0.11		0.07	4	80	Yes	BB	19
10	jjjj	Yes	-0.15					0.30	10	240	Yes	AA	22
11	kkkk	Yes	0.03					0.03	8	90	Yes	BB	17
12	llll	Yes	0.05					0.06	5	100	Yes	BB	18

Figure 60: Input in Workbook 7 'Semi-partial correlational data.xlsx'

4.4.3 Forest Plot sheet

If the number of observations is not inserted on the input sheet, the confidence intervals of individual studies cannot not be generated because they rely on a Student's *t*-distribution, for which

an appropriate degrees of freedom needs to be specified. This applies to the Subgroup Analysis sheet as well.

5 Adapting plots for reporting

In *Meta-Essentials* extensive use is made of the graphical displays available in Microsoft Excel. In order to fully benefit from these displays in a report, it might be useful to edit them. For instance, in a publication grey-scaled figures might be preferred. In Excel it is fairly simple to make changes according to one's preferences. Here a number of recommendations are discussed.

First, it is recommended to edit the displays in Excel **before** copying them to a word-processing program. In Excel (2010 and later), a 'Chart Tools' function will appear when a display is 'left-clicked'. Features such as colours, properties of the axes, size, titles, and labels can be changed. By 'right-clicking' on a chart and then selecting 'Select data', it is possible to change the items that are displayed in a graph. By default, the effect sizes of individual studies with their confidence intervals and the combined effect size with its confidence interval and prediction interval are displayed.

One can adapt the size of the forest plot on the Forest Plot sheet as well as on the Subgroup Analysis sheet. These charts show 200 studies by default (which is the current maximum number of studies that can be entered into a meta-analysis in *Meta-Essentials*). Usually, a (large) part of the graph will be empty. It is recommended to change the axis and size of the graph in Excel before copying it into a text document. Right-click on the vertical axis, click 'Format Axis' and change the parameter 'Maximum' under 'Axis options' to 'Auto' (or manually insert the number of studies included, plus one for the combined effect size, and plus the number of subgroups in case of the plot for Subgroup Analysis). Then scroll down towards the bottom of the figure and reduce the size of the chart area by drag-and-drop.

6 References

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